POWER

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ELY C. HUTCHINSON, *Editor*

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He Kept His Head

AT A recent meeting the following story was told:

In a certain coal mine about fifteen tons of water have to be pumped some six or eight hundred feet to the surface for each ton of coal won.

One day the pump tender at one of the underground pumping stations came running to the shift boss with the statement that a concrete bulkhead in the pump room had shifted and that the water was coming in at such a rate that it would put the pumps out of commission and flood the mine.

He excitedly implored the shift boss to sound the alarm and call the men out.

The boss answered by making his way to the scene of the trouble, grabbing as he went a blanket which he threw on the ground directly under the threatening structure. Turning to the pump tender he said, "Go tell the Old Lady I won't be home tonight. I'm sleeping here."

The bulkhead did not fail. In the presence of the boss confidence was restored and the pumps took care of the added leakage. Repairs were made under normal conditions and a fifteen-million dollar property remained in operation.

Just a shift boss—his name was not even mentioned when the story was told—but his judgment was good and he backed it up by staying where the trouble was, ready for the emergency if it came.

There are frequent instances in power plants where, in times of stress, men have averted danger to their associates and the surroundings and preserved valuable property by not losing their heads, knowing what to do, sticking to their posts and doing it.

I would not laud the foolhardiness that leads one to risk his own life and that of others to avoid a shutdown or to save property that can be replaced, but I do admire the grasp of the man who sees the way through a condition that would terrify the less fit and his coolness and courage in seeing it through.

F. R. Low

EDITORIALS

Engineers and Architects

ARCHITECTS responsible for the design of skyscrapers and other types of large buildings are confronted with the necessity of providing for the installation of an amazing amount of power service and mechanical equipment—equipment with which they are generally only slightly familiar. This often results in features of the building design being settled with but little reference to the power and mechanical needs.

An engineer is then called in by the architect, and is given the job of somehow squeezing into inadequate space all of the equipment necessary to provide the building with the many services demanded by the tenants. It is not surprising, under these circumstances, that installation costs are high and operation often difficult. In fact, that the equipment is installed and made to operate is in itself a tribute to the engineer's skill.

How much better it would be if the engineer were called in at the start of the project and given an opportunity to insist on adequate space for equipment, as well as to determine whether power and steam should be generated or purchased. The engineer should then be able to produce designs for heating, ventilating, water and power systems of which he may be proud, and which should result in installation and operating savings for the builder.

"Energy, Wild or Tame"

"ENERGY, WILD OR TAME" was featured in a recent number of the *Saturday Evening Post*. Garet Garrett was the author. In a style electric with interest, this master popularizer of economic thought painted an alluring picture of a coming Energy Age in which production of gas, electricity, coke and byproducts will be combined in a few great plants or generating groups. These, according to Mr. Garrett, will be located at points where coal, water and underground gas-storage space are available.

While Mr. Garrett neglects certain aspects of the problem—such as investment charges on long pipe lines, difficulty of providing storage at the receiving end to smooth out the load curves of the pipe lines, and the present commercial impracticability of transmitting electricity over great distances—his picture is not to be laughed off. There is already a trend toward transmitting gas and electricity over greater distances, and toward the combined manufacture of the various energy services.

But Mr. Garrett's opinions diverge sharply from those held by the majority of the mechanical engineers when he predicts a great future for the gas turbine. "But now," he says, "appears on the horizon an engine that will be called the gas turbine. The inventors of several countries are working on it. They almost have it. They know all the mechanical principles. What they need is a metal for turbine wheel blades that will bear up under terrific heat, for the turbine will have to work at a temperature comparable to the smelting furnace. Yet it is the story of modern science that what we know we want, we always find. The gas turbine will arrive. Take that for granted. The probability is that several types of it will arrive at once. Then further possibilities begin to open."

It might be inferred that the gas turbine is a new idea, whereas it is very old and experimental machines have been "appearing on the horizon" off and on for years. One may agree with Mr. Garrett that the problem of materials will eventually be solved and that mechanically workable gas turbines will be produced. In fact, these two objectives have already been attained in a measure. Yet the gas turbine cannot come into general use for large-scale power production until its efficiency compares favorably with that of steam plants, and this is not as simple as it looks.

Efficiency is closely related to the problem of compression, which is the economic Nemesis of gas-turbine projects. An efficient internal-combustion machine, reciprocating or turbine, must compress the air and fuel.

The reciprocating gas engine compresses with the same piston that later absorbs energy on the working stroke. Builders of gas turbines, on the other hand, are obliged to resort to a separate compressor element. Thereby two sets of mechanical losses are introduced, one in the turbine proper and one in the compressor. Since the compression work is, in any case, a large portion of the total work delivered during expansion, this pyramiding of mechanical losses is a bar to high over-all efficiency.

It seems, in short, that Mr. Garrett is over-optimistic on this point. But negative predictions are dangerous. Some remarkable new developments in turbine compressors may place the gas turbine eventually on the same performance plane as the reciprocating gas engine. If, with this, the cost can be kept substantially lower than that of steam plants, the gas turbine may become of some economic interest.

New Designs and Motor Applications

IF FULL advantage is to be taken of the recent improvements in induction motors and their control, traditions regarding them must be discarded. Formerly, motors of this type in sizes above five horsepower were started on reduced voltage. Modern designs, up to thirty horsepower, are now regularly started on full voltage, and for certain applications units of several hundred horsepower are started that way. Full-voltage starting has greatly simplified control equipment for these motors.

These changes in design not only affect new applications, but they also offer possibilities of economically revamping old installations that otherwise would not justify a change. If an old-type motor, started on reduced voltage, has to be rewound it may be more economical to install a new motor that can be started on full voltage. The efficiency of the new motor will probably be higher than that of the old, and the control will be much simpler. Simplifying the control reduces maintenance costs and increases reliability. Where drives have been overmotored, replacing the old motor with a new one will also give a material improvement in power factor—an important consideration in many plants.

The dip in voltage caused by induction-motor starting current has generally been offered as an objection, especially where lights are supplied from the same feeder. This has undoubtedly been exaggerated. Some household devices that are started frequently cause light flickers to which no serious objections are taken. If voltage drops caused by starting induction motors are kept within reasonable limits there should be no complaint. Increased size of generating equipment and feeders also allows starting induction motors on full voltage, where formerly this was objectionable. These and other improvements have changed the basis on which induction motors are selected and applied and offer many opportunities for reduction in costs and better service.

Lower Flue-Gas Temperatures

A LIMITING factor in boiler efficiency is the flue-gas temperature, the lower range of which appears to be from 210 to 250 deg. F. when employing both air preheaters and economizers. Experience indicates that rapid corrosion may occur in such equipment if the flue gas is cooled below these temperatures. Recent developments, however, indicate that it may be found both desirable and economical to cool the gas further.

Air preheaters are under development in Europe that are designed to cool the flue gas almost to the dew point. The cold ends of these preheaters employ stainless steel sheets, which, because of their thinness, keep down the cost.

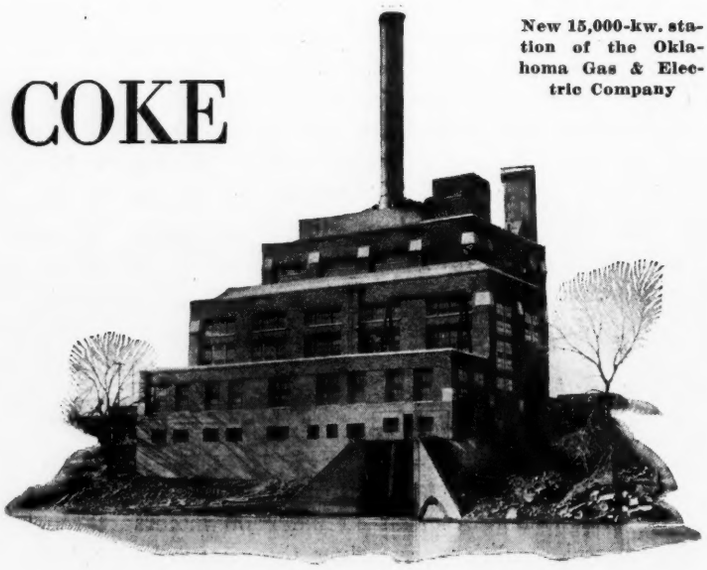
Another factor that may encourage further cooling of the flue gas is the increasing conviction that dust from chimneys must be reduced. One difficulty with usual gas-washing methods is that the fine dust particles are surrounded by layers of gas which prevent the particles from becoming wet. Hence these fine particles pass through the washer. A new plan, which has been tried out abroad with encouraging results, is to spray water as a fog or mist into the hot flue gas leaving the economizer or air preheater. This mist evaporates, lowering the temperature of the flue gas and increasing both the humidity and the dew point. A second set of sprays further cool the gas below the dew point. The vapor in the gas condenses on the dust particles as nuclei and because of the increase of weight the particles fall and are washed out.

Since this process involves a cooling of the gas, the question arises whether the heat available in the gas by this temperature drop might not be utilized by using stainless-steel air-preheater sections. If the gas can be cooled by an air preheater down to the dew point, which may be about 130 deg. F., the first set of sprays would not be necessary and the washing equipment would be simplified. Furthermore, this cooling would add to the boiler efficiency. Such possibilities warrant further investigation.

POWER *Stands for . . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

Burns PULVERIZED PETROLEUM COKE



New 15,000-kw. station of the Oklahoma Gas & Electric Company

LINCOLN BEERBOWER station a modern 400-lb. 750-deg. plant using welded boiler drums, and favored by a near-by supply of good fuel at low cost. Poor water makes necessary make-up evaporators and a closed condensate system featured by a steam-blanketed surge tank.

THE FIRST 15,000-kw. turbine-generator unit at the new Lincoln Beerbower station of the Oklahoma Gas & Electric Company recently went in service. A second unit of the same size at a later date will complete the station. The plant is on the Arkansas River, between Ponca City and White Eagle, in the northern division of the company. Necessity for the plant arose from increasing power demands from expanding oil-field developments and from flour mills and other industries located near by.

In the general design of the plant two factors had a predominating influence. One was the proximity of an excellent supply of petroleum coke from the oil refineries. The coke could be had at a favorable price, as the excessive supply in the locality had almost brought this residue into the class of a waste product. The coke has a heat value of about 14,000 B.t.u. per pound, the inherent moisture is low, and it is free burning. Considering price, quality and availability, the fuel supply is ideal. Decision was made to pulverize the coke and supply it to the furnaces by two unit mills per boiler.

The other major factor influencing design was a limited water supply from the Arkansas River. During low-water periods, which exist for many months of the year, the supply is scarce. At all times the water is heavy with mud and sand, and oil floats on its surface.

To provide suitable boiler water from this source required more than the usual treatment. Floating booms in the river keep the oil away from the screen house. In front of the screen house a concrete basin, or forebay, is constructed, so that the floor is 6 ft. below the river bottom. Flaring wing walls widen the intake to 60 ft., as compared to a width of 25 ft. for the screen house. In this way an adequate supply of condensing water is obtained under low-water conditions with reasonable freedom from sand, as much of the suspended matter will settle in the basin. Trash racks keep out the heavier débris, and traveling screens remove the finer material.

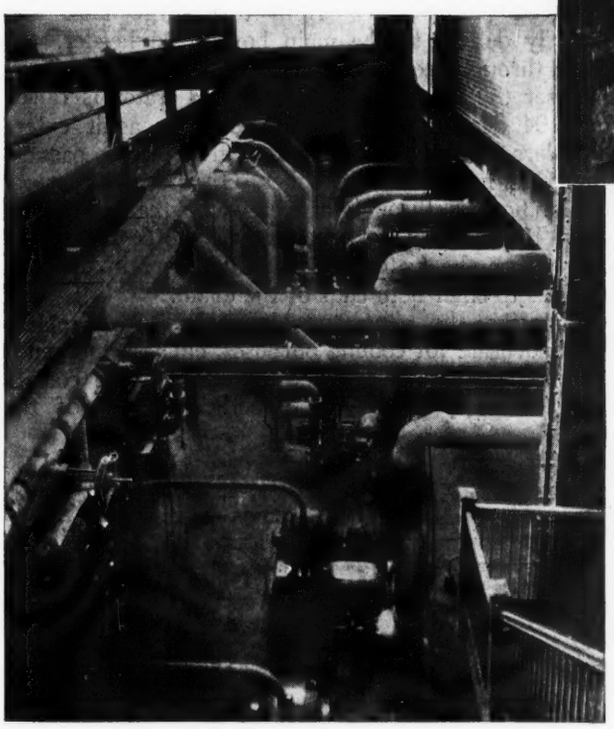
Condenser circulating and service pumps take their suction from the screen house well. As may be seen in Fig. 3, the run is comparatively short. Through a 30-in. pipe return water from the condenser is discharged back to the river at a point below the screen house, and during the colder months an 18-in. line carries part of this water to the intake basin to prevent formation of frazil ice.

Within the plant the service water from the river is first pumped to a large tank, where the heavier materials settle out. It is then passed through pressure-type gravel filters and is raised to one side of a 30,000-gal. roof tank divided at the center by a steel partition. Thus one half of the tank gives 15,000 gal. filtered water storage for plant use, and the other half furnishes storage for an equal amount of softened water, obtained by passing the water directly from the filters to a zeolite system before pumping it to the tank.

To provide boiler make-up, which, owing to the closed condensate system, should not exceed 1 per cent of the feed, the softened water goes to a single-effect evaporator having a capacity of 5,000 lb. per hour, and its vapor is delivered to an auxiliary condenser that receives as well the exhaust from the steam-driven auxiliaries, such as the boiler-feed and service pumps and a spare exciter. Condensation from this is pumped into the main condensate system, and thus pure boiler water is maintained.

For the present, two boilers have been installed, each having 12,780 sq.ft. of boiler-heating surface and rated to deliver 150,000 lb. of steam per hour at 400-lb. pressure and a total temperature of 750 deg. F.

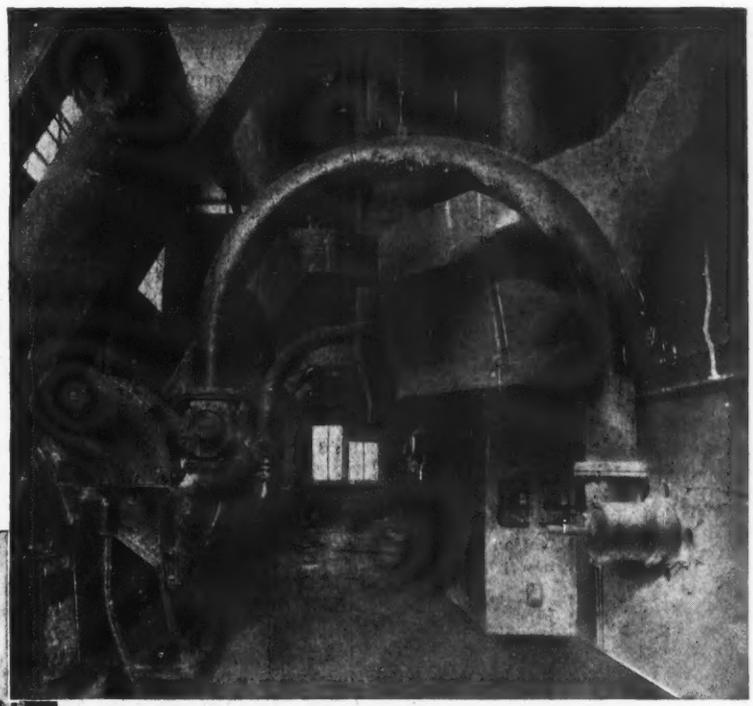
On boiler surface alone the foregoing capacity would mean operation at 400 per cent rating. Some assistance, however, is given by water surface lining the side walls of the furnace and that portion of the rear wall not occupied by a radiant superheater. This surface consists of bare tubes of 3-in. diameter on spaced $3\frac{9}{16}$-in. centers, all connected into the boiler circulation. The furnace front walls are air cooled. One boiler is able to supply the steam required by the turbine unit. With the installation of a second machine, another boiler will be added, so that one boiler always may be held in reserve. The boilers are of the cross-drum type, with the lower three rows of tubes designed as a slag screen. Three-pass baffling is arranged so that a large area is exposed to the radiant heat of the fire. A feature of the boiler design is the use of forged and hammer-welded drums, to eliminate excessive mechanical stresses common to riveted construction. To supply uniform superheat under varying load, combination convection and radiant superheaters are used. With the center of the boiler drum 33 ft. above the operating floor and the sloping bottom of the furnace extending down into a 20-ft. basement, it was possible to provide a furnace volume of 7,700 cu.ft. At a steaming rate of 150,000 lb. per hour, a heat release of 25,000 B.t.u. per cubic foot is obtained. Two 4-ton pulverizers per boiler supply fuel to the furnace through two horizontal, low-velocity, turbulent-type burners.



Turbine room basement showing feed pumps and neat piping arrangement.

Air preheaters are directly above their respective boilers. Design is of the improved regenerative type, in which both forced- and induced-draft fans are mounted on the same shaft. Air from the heater is brought down to the boiler front and, as secondary air, is introduced around the burners into the furnace. A small portion of it is used in the mills to mix with the fuel as primary air.

As the source of the fuel supply is a refinery about one mile distant, an interconnecting spur track was built, and over it the petroleum coke is transported to the plant in railway cars. With the surface of the site rising from the river, the track is brought in at the high side of the plant on an embankment high enough to permit excavation for a track hopper and skip hoist pit. Weighing is done on a track scale.



Boiler room showing ducts that carry air preheated to 475 deg.

Coke is delivered from the hopper by an apron conveyor to a crusher that discharges into the bucket of a vertical skip hoist. Located within and at the corner of the boiler room, the skip hoist functions automatically in connection with a larry traveling over the bunker. The hoist and the larry are operated from drums mounted on the same shaft and turned by a single motor. Both the larry and the hoist are timed to meet when the latter is at the top of its travel. As the hoist goes down for another load, the larry travels over the bunker to be tripped at any desired point.

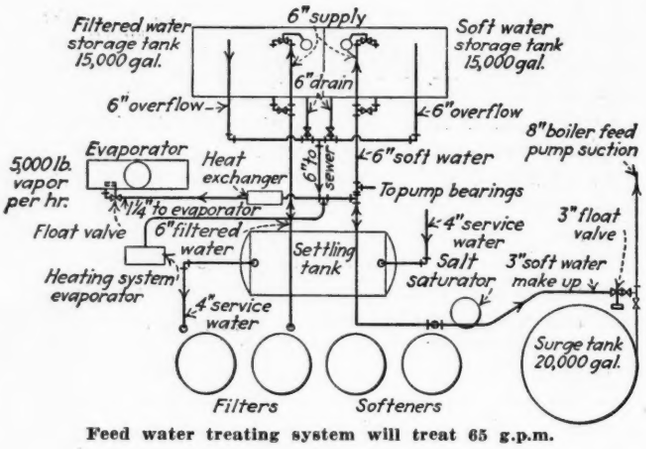
Ashes from each boiler furnace pass into a sluice hopper, where they are quenched by five ½-in. water jets on each side. During periods of removal, oscillating nozzles at both ends of the hopper wash the ashes into a trench to be flushed along, by water from a trench nozzle, to a storage pit located between the boilers. Through 6-in. lines two ash pumps remove the ash from the storage pit and discharge it to sections of the yard that require filling.

Special non-return valves of floating-piston streamline design were installed just above the superheater outlets. They were designed by Byllesby engineers for an extremely low pressure drop, about 2 lb., for the steam conditions at this station, as compared to guarantees of 8 lb. for standard stop valves. Their construc-

tion is simple, consisting of a ported cylindrical lining fitted into the valve body. A balanced streamline piston floats in this cylinder, with seats top and bottom to check its travel. Steam from the boiler enters at the bottom of the valve, causing the piston to rise and uncover the lower ports, so that the flow is through the bypass between cylinder and body and back into the line. Reduction of boiler pressure immediately allows the valve to close.

Accessibility and ease of control feature the layout in the turbine room. The main unit is a 15,000-kw. machine delivering three-phase current at 13,800 volts. The main crane has access to important auxiliary equipment, such as the boiler-feed and service pumps, a 125-kw. steam-driven spare exciter, and the vertical extraction heaters. All control valves for these heaters and for the condenser air evactor are operated from floor stands in the turbine room, equipment being so placed that the stands are in line and near the turbine throttle. Separated from the turbine room by a glass partition is the control room, with bench and vertical control boards and truck-type switchboard for auxiliaries.

Three-point extraction from the turbine gives steam at 4.5 and 69 lb., abs., for feed-water heating and a supply at 110-lb. pressure for the evaporator that provides pure make-up water. Vapor is discharged to a vertical condenser, which also receives the exhaust from the steam-driven auxiliaries.



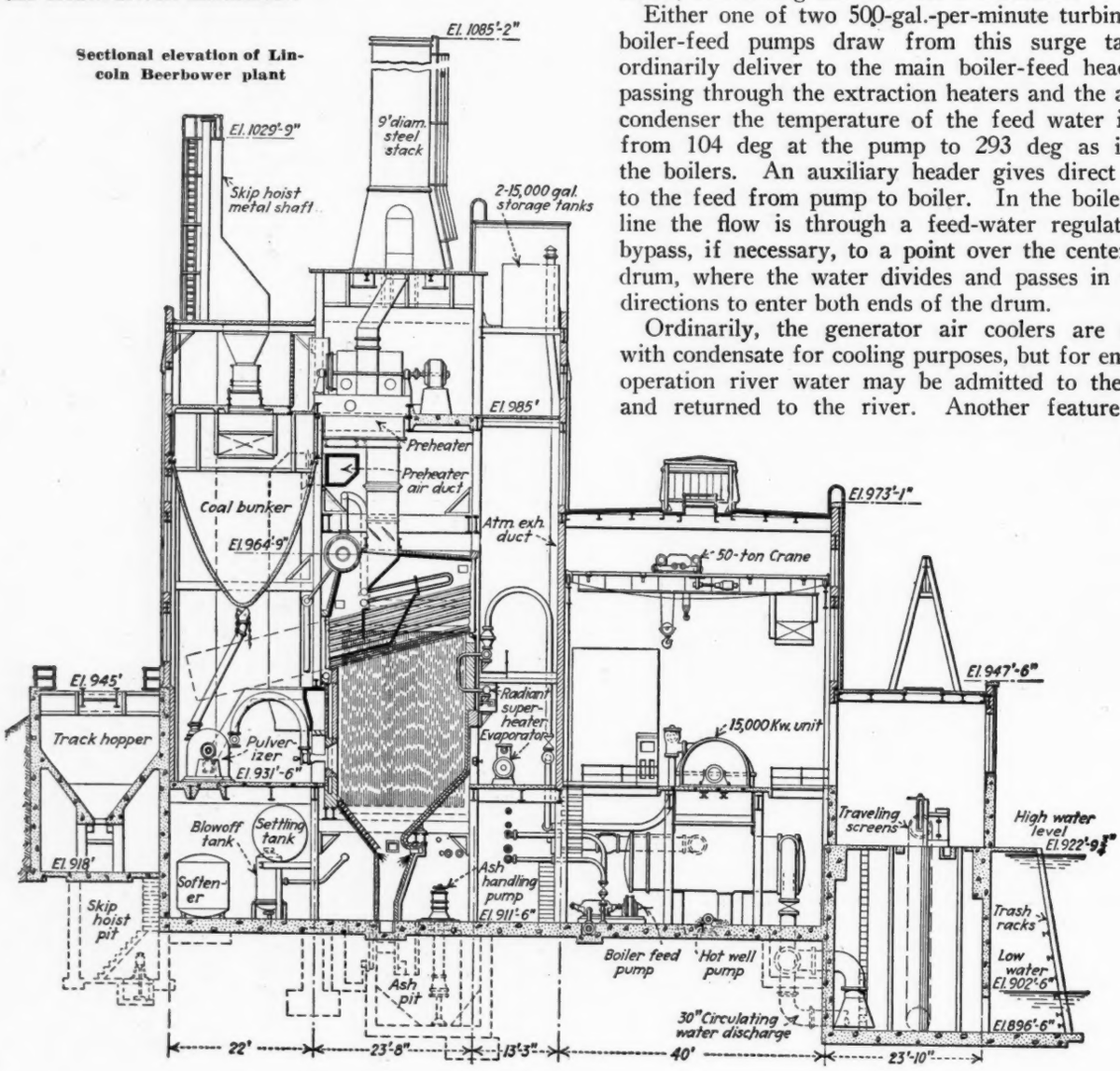
Feed water treating system will treat 65 g.p.m.

The condensate and boiler feed systems may be traced in the diagrams. The hot-well pump forces the condensate from the main condenser through the generator air coolers and the evactor directly to the boiler-feed pump suctions. A vertical surge tank is connected into the boiler feed pump suction line to provide for inequality of supply and demand. To keep the water in the tank from absorbing oxygen, a flat steel float of tank diameter rests on the surface of the water, and the upper portion of the tank is blanketed with steam, eliminating the need for a deaërator.

Either one of two 500-gal.-per-minute turbine-driven boiler-feed pumps draw from this surge tank and ordinarily deliver to the main boiler-feed header. In passing through the extraction heaters and the auxiliary condenser the temperature of the feed water is raised from 104 deg at the pump to 293 deg as it enters the boilers. An auxiliary header gives direct passage to the feed from pump to boiler. In the boiler supply line the flow is through a feed-water regulator or a bypass, if necessary, to a point over the center of the drum, where the water divides and passes in opposite directions to enter both ends of the drum.

Ordinarily, the generator air coolers are supplied with condensate for cooling purposes, but for emergency operation river water may be admitted to the coolers and returned to the river. Another feature of the

Sectional elevation of Lincoln Beerbower plant



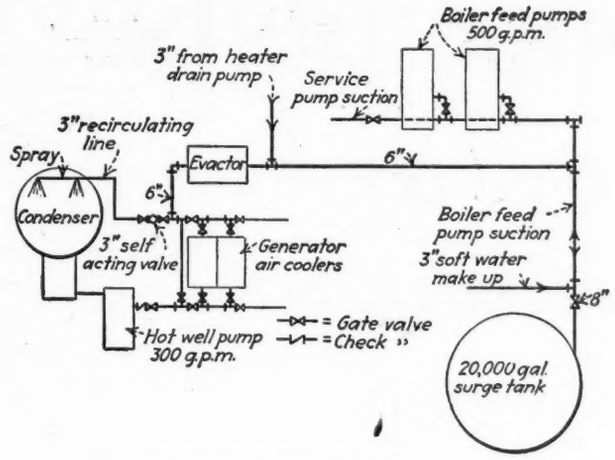


Diagram of condensate system

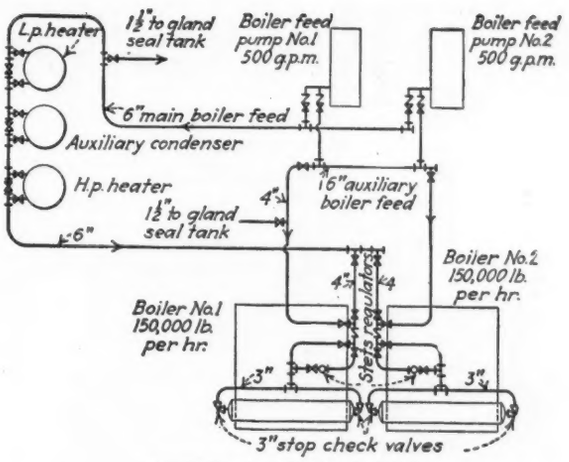


Diagram of boiler feed system

condensate system is a recirculating line through which a portion of the condensate after passing through the air coolers may be returned and sprayed into the condenser for cooling. This provides an increased quantity of condensate in case its temperature on either light or heavy loads becomes too high to cool the generator air.

A 18,750-kva. generator delivers 3-phase, 60-cycle current at 13,800 volts to an outdoor substation some 600 ft. from the power house. Necessary control boards and switchboards are in a gallery on the west side of the turbine room.

As is customary in all Byllesby subsidiaries, the plant was designed and the construction carried out by the Byllesby Engineering & Management Corporation, of which H. W. Fuller is vice-president in charge of engineering and construction.

Principal Equipment in the Lincoln Beerbower Station

Boiler Equipment

Boilers, two, sectional header, cross-drum, 450-lb. pressure, 12,780 sq. ft. each, 150,000 lb. steam per hour; drums forged and hammer welded ..... Springfield Boiler Co.
Furnaces, two, water cooled, 3-in. bare tubes on 3 9-16-in. centers, 1,260 sq.ft. ..... Springfield Boiler Co.
Front furnace walls, ventilated ..... M. H. Detrick Co.
Superheaters, two, combination convection and radiant; steam temperature at maximun rating, 750 deg. F ..... Foster Wheeler Corp.
Burners, two per boiler, flare-type ..... Riley Stoker Corp.
Furnace lighting equipment, permanent ..... S. F. Bowser & Co.
Air preheaters, two, Ljungstrom regenerative type with integral forced- and induced-draft fans of 55,000 and 80,000 c.f.m. capacity. ..... Air Preheater Corp.
Air preheater drive, 2,200-volt three-speed motor; 50-125-250 hp.; 600-900-1,200 r.p.m. ..... Westinghouse Elec. & Mfg. Co.
Stack, steel, self-supporting, 9 ft. diameter, 80 ft. high ..... Kansas City Structural Steel Co.
Soot blowers ..... Diamond Power Specialty Corp.
Feed-water regulators ..... Stets Co.
Blowoff valves ..... Yarnall-Waring Co.
Safety valves ..... Crosby Steam Gage & Valve Co.
Boiler check valves ..... Byllesby design
Water columns ..... Yarnall-Waring Co.

Meters

Boiler meters ..... Bailey Meter Co.
Venturi water meters ..... Simplex Valve & Meter Co.
Draft gages ..... Bailey Meter Co.
Thermometers, recording ..... Bristol Co.
Thermometers, indicating ..... C. J. Tagliabue Mfg. Co.
Leakage detector, condenser water ..... Esterling-Angus Co.

Coal and Ash Handling Equipment

Track scale, four-section, 50 ft. effective rail ..... Standard Scale & Supply Co.
Locomotive crane, one, 55-ft. boom. ..... American Hoist & Derrick Co.
Receiving hopper gates, four, slide-roller type ..... R. H. Beaumont Co.
Apron feeder, one, 30-in., 60 tons per hour, magnetic separation ..... R. H. Beaumont Co.
Coal crusher, one, double-roll, 30 x 30 in., 60 tons per hour ..... R. H. Beaumont Co.
Skip hoist and accessories ..... R. H. Beaumont Co.
Tram car, one ..... R. H. Beaumont Co.
Pulverizing mills, two per boiler, 8,000 lb. per hour, each driven by 100-hp. G.E. motor ..... Riley Stoker Corp.
Ash hoppers, sectional cast-iron, refractory-lined, complete with target plates, hyd. gates and oscillating nozzles ..... Allen-Sherman-Hoff Co.
Ash-removal pumps, two, vertical, manganese steel, 720 g.p.m. at 97-ft. head; G.E. 40-hp. motor, 440 volt, 720 r.p.m. ..... Allen-Sherman-Hoff Co.
Ash-sluicing pump, 700 g.p.m. at 250-ft. head, 1,750 r.p.m.; 75-hp. Fairbanks-Morse 2,200-volt motor ..... Manistee Iron Works Co.

Feed-Water Treating and Heating

Zeolite system, 75 g.p.m.—Filters, two, 7-ft. 6-in. diameter, 8-ft. 2-in. high, 100-lb. working pressure; softeners, two, 8-ft. diameter, 7-ft. high, 100-lb. working pressure ..... Permutit Co.
Evaporator, one, single-effect, horizontal, submerged type, 100-sq.ft. heating surface ..... Croll-Reynolds Engr. Co.
Closed heaters, two, vertical, floating-head type, 695 sq.ft. each, 4-pass ..... Croll-Reynolds, Engr. Co.
Auxiliary condenser, one, vertical, floating-head type, 695 sq.ft., 4-pass ..... Croll-Reynolds Engr. Co.
Heater drainers ..... Atwood & Morrill Co.
Heater drain pump, 90 g.p.m. at 49-ft. head, 1,750 r.p.m., motor drive ..... Worthington Pump & Mach. Corp.

Boiler-Feed and Service Pumps

Boiler-feed, two, 8-stage, 500 g.p.m. at 1,260-ft. head, 2,800 r.p.m.; drive 265-hp. Terry turbine ..... Manistee Iron Works Co.
Service pumps, two, 1,000 g.p.m. at 234-ft. head, 1,800 r.p.m.; drive, Terry turbine or 100-hp. G.E. motor ..... Manistee Iron Works Co.

Turbine-Generator and Auxiliaries

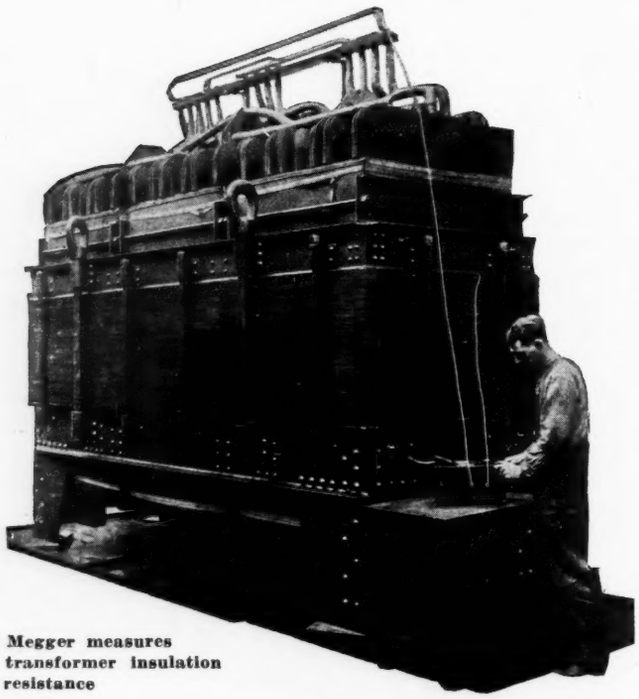
Turbine-generator, one, 15,000-kw., 3-stage bleeding, 1,800 r.p.m.; generator 3-phase 60-cycle, 13,800 volt ..... General Electric Co.
Generator air cooler, 10,420 sq.ft. ..... General Electric Co.
Oil-purification system ..... S. F. Bowser & Co.
Condenser, 2-pass, 15,000 sq.ft. ..... Allis-Chalmers Mfg. Co.
Circulating pump, vertical 21,000 g.p.m. at 18-ft. head, Westinghouse motor, 125-hp., 2,200 volt, 300 r.p.m. ..... Allis-Chalmers Mfg. Co.
Condensate pump, 300 g.p.m. at 100-ft. head; 12.6 hp. Terry turbine drive ..... Allis-Chalmers Mfg. Co.
Air evactor, twin, 3-stage, with inter and after-coolers, Croll-Reynolds ..... Allis-Chalmers Mfg. Co.
Traveling screens, two, 26 ft. ..... Chain Belt Co.

Miscellaneous Equipment

Air compressor, one, 253 c.f.m., 100-lb. pressure, motor drive ..... Chicago Pneumatic Tool Co.
Crane, turbine room, 50-ton, 4-motor, 38-ft. span ..... Harnischfeger Corp.
Motor valve operators ..... Limitorque Corp.
Pipe, valves and fittings ..... Crane Co.
Insulation, boilers and pipe ..... Armstrong Cork & Insulation Co.

TRANSFORMER TESTS

Used in Maintenance Program



Megger measures transformer insulation resistance

By A. A. FREDERICKS
New York City

Simple tests that may be applied to transformers to determine the polarity of the leads, the condition of the oil and insulation, and the tightness of the tank, and to locate leaks in the cooling coils.

BEFORE transformers are put into service, tests should be made to determine if they are fit for operation and if the internal connections are correct. Some users test all transformers as received from the manufacturer and also test any transformer that is taken out of service and put into storage. Test should be made on the insulation and the oil, and if they are not up to standard they should be put in good condition. If the polarity of a transformer is not known, a check should be made to determine if the leads are correctly arranged. The tank should be tested for oil leaks, and on water-cooled transformers the cooling coils should be checked for leaks.

Figs. 1 and 2 show the arrangement of leads on a simple distribution transformer as recommended by the National Electrical Manufacturers Association (N.E.M.A.). Fig. 1 shows the arrangement of leads for subtractive polarity and Fig. 2 for additive polarity. It is recomemnded that for all single-phase distribution transformers in size of 200 kva. and smaller the high-voltage ratings of which are above 7,500 volts, the standard polarity be subtractive. For distribution single-phase transformers in size of 200 kva. and smaller the high-voltage ratings of which are 7,500 volts and below, the standard polarity should be additive. The standard polarity for single-phase transformers in size above 200 kva. should be subtractive irrespective of voltage rating.

If the leads of the transformer are marked according to the N.E.M.A. standard, then when the H_1 and X_1 leads are connected together as in Fig. 3 and voltage is applied to the high-voltage winding, the voltage between the highest numbered H lead and the highest numbered X lead should be less than that applied to the high-voltage winding. In Fig. 3 if the transformer has a ratio of 10 to 1, the voltmeter should read $220 - 22 = 198$ volts. If there were no marking on the transformer leads and a test made as in Fig. 3 and a voltage reading obtained less than that applied to the high-voltage winding it would be known that the transformer had subtractive polarity, and the leads should be marked according to Fig. 1.

If a transformer's leads are marked as in Fig. 2, indicating additive polarity, a check can be made for the proper arrangement of leads, as in Fig. 4. The H_1 and X_1 leads are connected together and a voltmeter reading taken from the highest numbered H and X leads. If the transformer leads are arranged for additive polarity the voltmeter reading will be less than the voltage applied to the high-voltage winding. If the voltmeter reading is higher than the voltage applied to the high-voltage leads it shows that the leads have been brought out of the transformer incorrectly.

It is essential that the polarity of all transformers be known when they are connected in parallel, otherwise there is danger of having a short circuit between them. When two transformers are connected in parallel a check can be made on the connections as in Fig. 5. A piece of light fuse wire is connected in the low-voltage connections as indicated. Then without any load on the low-voltage side close the high-voltage switch. If the transformers are connected correctly the fuse will not blow, in which case the high-voltage switch is opened, the fuse wire removed and the low-voltage connections completed. Should the fuse blow, it shows that a short circuit exists between the transformers and must be corrected. Trouble of this kind is usually due to the two transformers not being of the same polarity. If

this were the fault, the transformers could be operated in parallel by connecting them as in Fig. 6. Before making these connections permanently they should be tested as explained for Fig. 5. Fig. 7 shows how to check the connections of a delta-to-delta connected bank of transformers.

Making Tests on Oil

Oil should be tested to make sure that it is dry before it is placed in a transformer. A standard method of testing oil for dryness is to use a spark gap consisting of two round disks one inch in diameter and set 0.1 in. apart. The disks are immersed in an oil sample and voltage applied. Transformer oil to be in good condition must not fail at less than 22,000 volts, although oil in use is generally considered safe until its dielectric strength falls below 18,500 volts. Oil in exceptionally good condition will test up to as high as 28,000 volts. Fig. 8 shows a cross-section of an oil test cup. The gap terminals *G* are flat disks one inch in diameter and held in the cup by adjusting nuts. A gage *A* 0.1 in. in diameter is provided for setting the gap. When the gage is not in use it is screwed into one of the test terminals, as shown.

Care must be taken if accurate test results are to be obtained. The oil cup must be clean. The test cup must be wiped out with a dry cloth and no fibers allowed to adhere to its surface. Small fibers left in the cup may float into the gap and cause the oil to break down at a lower voltage than it otherwise would.

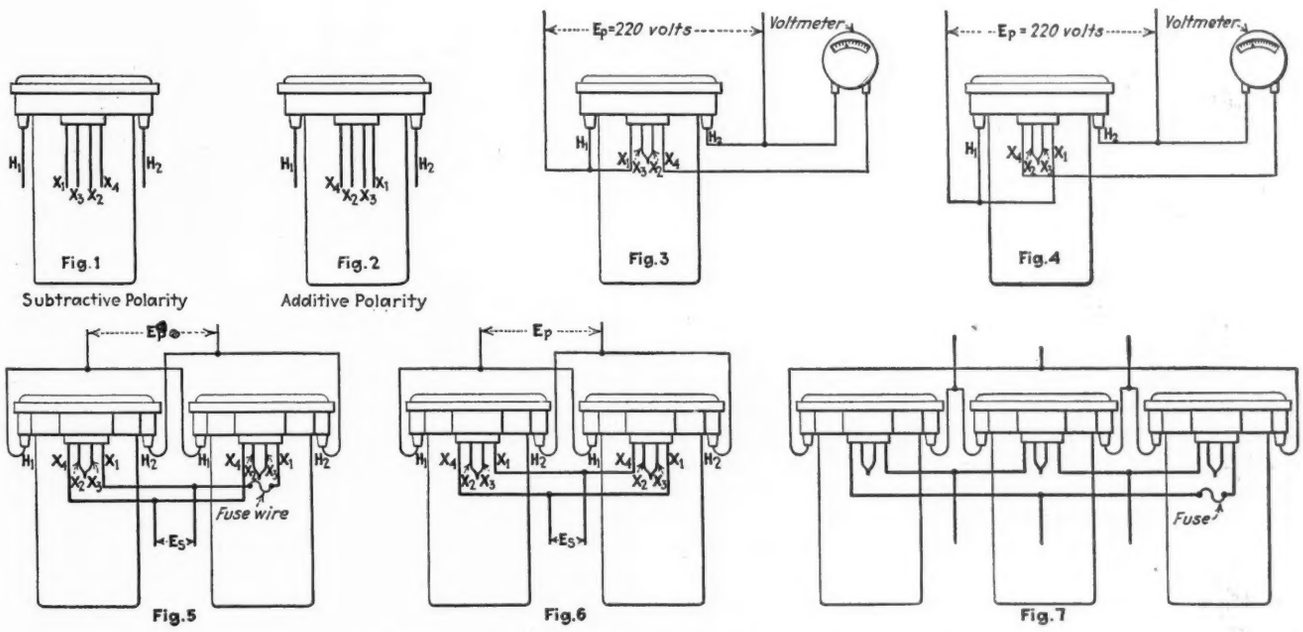
When the gap has been adjusted to 0.1 in. rinse out the cup with gasoline or benzine. Just before making the test give the cup a final rinsing with some of the oil to be tested. The test sample should fill the cup to one inch above the gap. When the sample has been poured into the test cup it should be allowed to remain two or three minutes, until all the air bubbles have had time to escape. The temperature of the oil and the cup should be about the same, between the limits of 20 and 30 deg. C. (68 and 86 deg. F.). Voltage values at which oil will break down are likely to vary with temperature, decreasing slightly as the temperature decreases.

A standard testing transformer that can have its voltage adjusted up to about 30,000 volts should be used to make the test. This allows determining the voltage value at which the oil will break down. In the absence of such testing set a transformer that will give about 20,000 volts can be used. If this voltage is applied to the sample and it does not fail, the oil is known to be in safe condition. If the oil breaks down it should be treated in a filter press or centrifuge. If facilities are not available for treating the oil, it should be replaced by oil that tests up to standard. Even new oil should be tested when received, for unless extreme precautions are taken moisture is likely to get into it in transit. Eternal vigilance is part of the price that must be paid if dry oil is to be had in transformers.

Intervals Between Tests

When transformers are in service the oil must be checked periodically. Intervals between tests may range from every two years or more for small distribution transformers to every month for large water-cooled transformers. For the average conditions under which oil-insulated, self-cooled power transformers operate, testing the oil once every twelve months is good practice. The N.E.M.A. recommends that samples of oil from all power transformers be drawn and tested at least every 6 months. Oil samples should be drawn from the bottom of the tank each week and tested during the first month of service of transformers having a potential of 40,000 volts and over. If at any time the oil tests below 16,500 volts it should be filtered.

An oil sample should be drawn from the bottom of the tank, as any moisture in the oil will settle there. If facilities are not available for obtaining the sample from the bottom of the tank a long tube may be used. The top end of the tube is closed with the thumb, as in



FIGS. 1 TO 7—DIAGRAMS SHOWING POLARITY OF TRANSFORMERS AND HOW TO TEST THE CONNECTIONS FOR CORRECT POLARITY

Fig. 1—Leads marked to indicate subtractive polarity. Fig. 2—Leads marked to indicate additive polarity. Figs. 3 and 4—Connections for checking the polarity of transformers to see if the marking on the leads are correct. Fig. 5—Fuse wire used to check the connections of two transformers connected in parallel. Fig. 6—Two transformers of opposite polarity connected in parallel. Fig. 7—Fuse wire used to check the connections of three transformers grouped in delta.

Fig. 9, and then placed vertically into the oil until the lower end of the tube is at the bottom of the tank. All this time air has been retained in the tube and it cannot fill with oil. Removing the thumb from the tube allows oil to flow into it from the bottom of the tank. The top of the tube is again closed and the sample removed.

Containers for the sample should be large-mouth glass bottles that have been thoroughly cleaned, rinsed with gasoline or benzine and allowed to dry. About a quart of the oil should be taken as a sample. If drawn from the bottom of the tank through a sampling pipe, enough oil should be allowed to run out to insure obtaining a sample from the bottom of the transformer and not that in the sampling pipe. If facilities are not available for testing the oil, the sample may be sent to the transformer

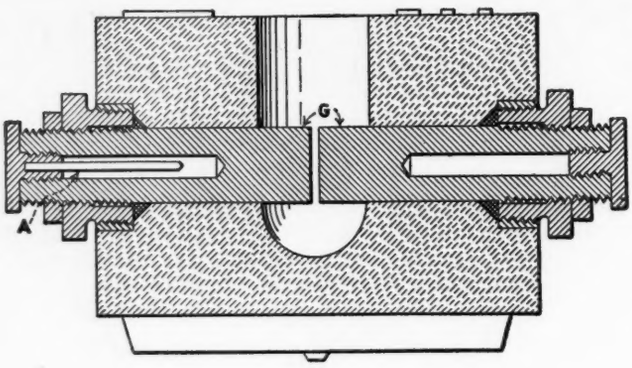


Fig. 8—Section through oil-testing cup

manufacturer or a laboratory equipped to do such work. It probably will not pay to test the oil of small-capacity transformers, and it should be renewed every three years.

All transformer joints must have good gaskets and be made up tightly, or there is danger of moisture getting into the oil. After the cover has been put on the transformer it may be subjected to a pressure test. A small hand air pump provides an easy way of doing this. A valve should be placed in the connection between the pump and transformer, with a pressure gage between the pump and the tank. When pressure in the transformer has been brought up to about 10 lb. the valve is closed tightly. The pressure should be kept constant for about five minutes. Leaks can be detected by bubbles that will form in soap suds which have been smeared over the joints.

After cleaning the coils of water-cooled transformers, some operators test them by closing one end of the coils and applying oil under pressure. The coils are first blown dry with air, after which a hand pump is used to fill them with oil. When the discharge ends of the coils have been capped or plugged the pump is again operated to raise the pressure to double the maximum working pressure. When this is reached the valve in the pump discharge is closed and pressure allowed to remain on the coils. If, after an hour or more, there is no change in pressure but what can be accounted for by a change in temperature it is safe to assume that the coils do not leak. The object of using oil instead of water to make the test is to prevent water from getting into the oil in case of a leak.

Before placing new water-cooled transformers into service, N.E.M.A. recommends testing the cooling coils for leaks at a pressure of 80 to 100 lb. per square inch. Water, oil, or, preferably, air may be used to obtain the pressure. The coils must be removed from the tank if water is used so that, in case of a cooling-coil failure, water will not get on the windings. When the desired pressure is obtained, close the coils with a valve, and after an hour determine if any fall in pressure is due to a leak in the coils or in the fittings at their ends.

Before going into service a new transformer is generally subjected to a high-voltage test. The A.I.E.E. standard test is: Transformers for primary pressures from 550 to 4,500 volts shall be tested with 10,000 volts from the primary to the core and secondary combined. The secondary winding shall be tested with twice normal voltage plus 1,000. For all transformers designed for a higher voltage than those just mentioned the test voltage shall be twice normal plus 1,000, applied for one minute. Such a test to a transformer after it has been in service is not approved by many operators. It is maintained that even though the transformer does not fail, the test may have injured the insulation and will cause it to fail at some other time. Other operators are in favor of a high-voltage test wherever transformers are given a general overhauling. However, in any case a high-voltage test should be used with discretion.

Although it does not show the ability of the insulation to stand high voltage, an insulation resistance test is a very good guide to the general condition of the insula-

Fig. 9—Obtaining an oil sample from the bottom of transformer tank with a thief tube

tion and is to be recommended. The most satisfactory method of measuring resistance is with a Megger. This instrument is easily applied and gives a reading of the insulation resistance directly in megohms. When the insulation resistance does not measure less than 1 megohm for each 1,000 volts of normal operating value, the transformer's insulation may be considered safe. Applying this rule to a 6,600-volt transformer would require that the high-voltage winding have an insulation resistance of 6.6 megohms. If the insulation resistance falls below the value of 1 megohm for every 1,000 volts of rated voltage the transformer should be dried out.

There are three methods of drying out transformers, by internal heat, by external heat and by a combination of both. When the internal heat method is used the coils may be dried out in the oil, or they may be dried out after the oil is removed. Using the first method the

coils and oil are heated to a high temperature for a limited time by passing current through the coils. The usual method of providing the heat is to short-circuit the low-voltage winding and apply sufficient potential to the high-voltage winding to give the desired heating current. Usually less than 5 per cent of the normal volts will be required to circulate the current in the winding. The table gives the short-circuit current in per cent of full-load current recommended by N.E.M.A. The temperature limits and loads should be adhered to in order to obtain the desired results without endangering the transformer.

Short-Circuit Amperes in Per Cent of Full Load		Maximum Top
Self-Cooled Transformers	Water-Cooled Transformers	Oil Temperature
50	50	85 Deg. C.
75	60	80 Deg. C.
85	75	75 Deg. C.

The table indicates that in a self-cooled or a water-cooled transformer a maximum oil temperature is allowed if the short-circuit current does not exceed 50 per cent full-load rating. If the oil temperature is below this value with 50 per cent full-load current in the low-voltage winding, it can be raised by blanketing the transformer's tank. It should be noted that the heavier the load on the transformer the lower is the allowed oil temperature. The difference is to prevent injuring the winding or oil by hot-spot temperatures. When a transformer is being dried out by this method good ventilation must be provided over the oil to carry away the moisture. A desk fan may be used to blow air across the top of the oil. Time required to do the drying will vary from one to three weeks. During the drying process, tests should be made on samples of the oil taken from the bottom and top of the tank.

Another way to dry out a transformer is to remove the oil from the tank and apply internal heat by the short-circuit method. The cover should be left off the tank to allow free circulation of air around the coils. Sufficient voltage is impressed on the high-voltage winding to circulate a heating current that will maintain a temperature of 75 to 80 deg. C. About one-fifth normal full-load current is usually sufficient and will require from ½ to 1½ per cent rated volts applied to the high-voltage terminals. This method should be used on small transformers only.

When external heat is used, a box is built around the transformer and heat is supplied from an external source to the bottom of the box. A preferred method of supplying the heat is by electric heaters. The clearance between the side of the box and the transformer should be small so that most of the heat will pass through the ventilating ducts of the coils. The coils should be carefully protected against direct radiation of the heat or the insulation may be injured. Temperature limits are the same as when internal heat is used, as is likewise the time required for drying.

In some cases a combination of the external and internal heat methods is used. Then the winding current is less than when internal heat is used alone. The temperature limits are 75 to 80 deg. C. In any of the drying processes an insulation resistance curve should be plotted, with time as abscissas and resistance as ordinates. A point in this curve can be found where the resistance starts to increase more rapidly than at first. It is generally good practice to continue the drying process beyond the knee of the curve, for about 15 per cent of the time required to reach the knee. In general, it will be found that the insulation resistance of a transformer will decrease when the drying process is first started, but will gradually start to increase in value as the temperature becomes constant.

Fig. 10—Checking transformer load with ammeters and split-core current transformers

Ammeters with split-core transformers make a convenient outfit for checking the load on transformers, as indicated in Fig. 10. Making load tests was discussed more fully in the article on transformer maintenance in last week's number of *Power*.

Boiler Equipment for Fremont, Neb., Municipal Light Plant

THE CITY of Fremont, Neb., has had a municipal light and water system for years. Increase in the demand has necessitated additions from time to time, and recently the city, through Burns & McDonnell Engineering Company, asked for bids on a new boiler, stoker, air preheater and economizer. The quotations received are listed:

BOILER

Bidder	A	B	C
Type of boiler	Cross Drum	Long Drum	Long Drum
Heating surface, sq.ft.	6,044	6,050	6,080
Working pressure, lb. gage	325	300	300
Superheat at 250 per cent rating, deg. F	172	....	170
Pressure drop at 250 per cent rating, lb.	10	....	7
Draft loss through boiler, 250 per cent rating, in.	....	0.65	0.85
Exit gas temperature, 250 per cent rating, deg. F	....	....	600
Cost boiler, superheater and soot blowers	$16,580	$14,485	$14,311

AIR PREHEATER

Bidder	A	C	G	H
Type	2-Pass Plate	Plate elements	Plate	Plate
Heating surface, sq.ft.	3,040	3,040	2,484	2,478
Draft loss 250 per cent rating, in.	0.55	0.78	.....	0.41
Cost without induced draft fan	$3,495	$3,390	$4,435	$3,982

STOKER

Bidder	C	D	E	F
Type	Underfeed	Underfeed	Underfeed	Chain
No. of retorts	6	6	7	..
No. of tuyeres	25	25	34	..
Coal, lb. per sq.ft. at 250 per cent rating	55.4	47.5	47.1	50
Furnace efficiency at 250 per cent	77.5	74	80	77
Cost stoker and forced draft fan	$8,907	$9,400	$8,628	$9,060

ECONOMIZER

Bidder	A	G
Heating surface, sq.ft.	791	864
Draft loss at 250 per cent rating, in.	0.4	125
Cost with induced-draft fan	$5,250	$4,500

1,000-Ton Plant for REFRIGERATION at Hershey's

Almost everyone has tasted the delights of a Hershey bar. But it is not generally known that the uniform high quality of this delectable bit of chocolate and nuts is due to the refrigerating system in the Hershey Chocolate Company's plant at Hershey, Pa.

WHILE a chocolate bar will stand a marked change in the weather, its quality is enhanced by being held at a uniform temperature until shipment is made to the retailer. But the largest part of the refrigeration is applied to the cooling of the chocolate products immediately following the process of molding. Previous to molding, the chocolate must be warm enough to spread perfectly into forms, which are conveyed through cooling chambers wherein cold air is circulated. The air leaves the bunker rooms, where it is cooled by direct expansion ammonia coils, at a temperature varying from 20 deg. to 30 deg. F., according to requirements. Rooms where the goods are wrapped, labeled, packed and stored must also be kept at a temperature of about 68 deg., never to exceed 70 degrees.

Hershey's has a 1,000-ton motor-driven refrigeration plant to supply this low temperature. Originally, the plant was made up of two 40-ton York vertical single-acting duplex machines, and as they were installed in a day when the corliss was the most economical engine, each compressor was direct coupled to a horizontal corliss engine.

With expansion of the company more refrigeration was needed, which called for more compressors. This led to the installation of a 160-ton 18 x 32-in. Frick vertical duplex single-acting compressor direct connected to a horizontal corliss engine in 1914. Later, a 160-ton De LaVergne horizontal double-acting compressor direct connected to an Ames 18 x 24 in. 150 r.p.m. uniflow engine was added. This engine was designed to operate condensing in summer and to exhaust at 3 lb. pressure into the heating system in winter.

In the meantime the company had built a modern condensing steam-turbine plant, and it was obvious that this plant could deliver power to motor-driven compressors at a cost far below that of the usual steam-driven compressors. Consequently, when a further extension of capacity became necessary motor-driven compressors were installed.

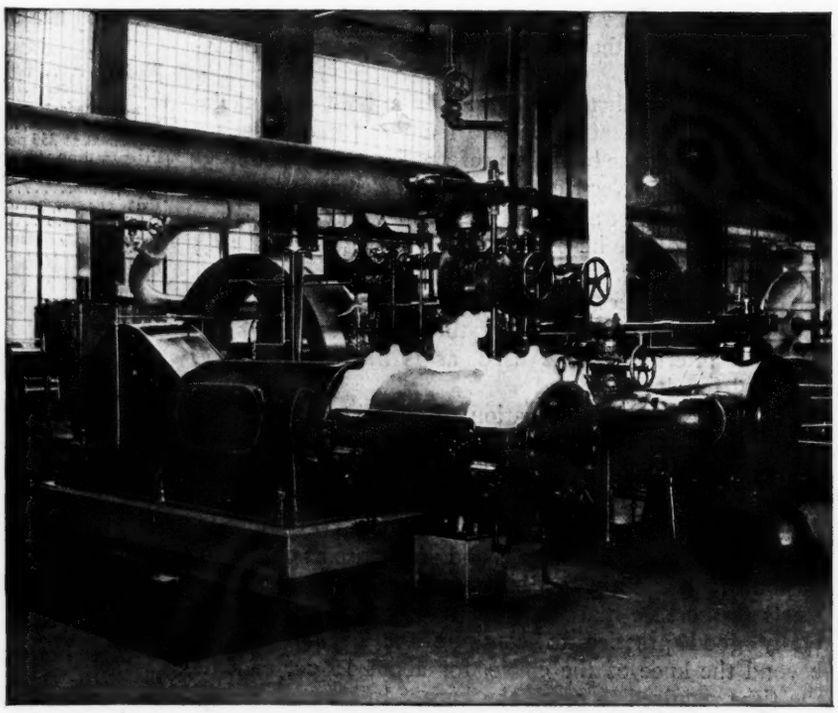


Fig. 1—The uniflow engine and its direct-connected compressor

At present the plant contains, other than the machines already mentioned, two 210-ton 15 x 18-in. De LaVergne horizontal duplex compressors direct connected to 400-hp. 180 r.p.m. G.E. synchronous motors, one a two-voltage, 900-to-2,300-volt machine. In addition there is a 130-ton 14 x 16-in. York vertical duplex single-acting compressor direct connected to a 300-hp. 225-r.p.m. synchronous motor with push-button control.

The uniflow engine-driven compressor is operated during the winter, with the exhaust entering the heating mains. This reduces the cost of the compression power to a point far below that possible from the condensing steam turbine plant supplying power to a factory. During summer months the machine is run much of the time, as long as low-pressure steam is needed.

Valve gear is of the variable-speed type, incorporating a Stephenson link, with the throw under control of the shaft governor. To operate the engine at a given speed a hand wheel is used to shift the link block, and the governor then regulates the engine at the new speed. This arrangement permits the compressor to run at the speed best suited to the rate of evaporation in the coils.

The horizontal motor-driven compressors are fitted with clearance pockets, the control wheels of one appearing in Fig. 2. This permits reduction of compressor capacity at a constant motor speed.

The pockets are of different volumes, so that it is possible by opening the proper combinations to reduce the compression volume to any desired value, thereby permitting variable capacity at constant volume. However, it should be understood that while the compressor's efficiency is but slightly altered at capacity changes, the motor efficiency is lower at reduced outputs.

A somewhat unusual operating detail is the wet compression cycle followed. To prevent piston-rod heating, a liquid line is led to each suction elbow and enough liquid is fed to keep the elbows well frosted.

While, theoretically, a dry-saturated condition of the suction gas as it enters the cylinder gives a compression efficiency higher than that obtained with either superheated gas or an over-saturated suction vapor, this advantage must be sacrificed at times to improve operating conditions. With an uncooled cylinder of the double-acting type, especially where it is subjected to a varying load and a fluctuating condition of the suction gas, attempts to operate on the dry cycle may lead to overheating of the rods.

The degree of frosting, or wet compression, is regulated in accordance with the machine's temperature. In no event is the liquid ammonia admitted in such quantity as to have a perceptible effect on the discharge temperature. In other words, it is not wet compression but a cool piston rod that is desired and obtained.

The cooling system includes holding the storage rooms at definite temperatures and the manufacturing rooms at the best operating temperatures. In fact, by reason of the openness of the mill floors, the cooling effect exists to some degree throughout the factory.

Only one suction pressure, 15-lb. gage, is carried, and the compressors are discharged into a common heater leading to the condensers, placed outside the machine room.

Three different types of condenser are used, atmospheric, double-pipe and shell-and-tube. These all operate in parallel without difficulty, one or two taking all the load.

Almost all of the piping has welded parts, although a few gasketed flanges are in use. Each of the compressors is provided with a check valve in the discharge.

While a brine system has the advantage that there may be considerable refrigeration storage in the brine, which permits a temporary shutdown of the plant, there is always a danger of damage to the stored goods from leaking joints, and the additional temperature difference between the cold-storage room and the ammonia in the brine coolers reduces the efficiency of the system. In the Hershey plant all of the refrigeration is handled by direct expansion of the Ammonia, which entails thousands of feet of pipe and an ammonia charge that would stagger the operator of a brine system.

A complete set of operating records is kept, and it is possible to compute daily the power consumption per ton of refrigeration and plot this against the tonnage of factory output and the outside temperature.

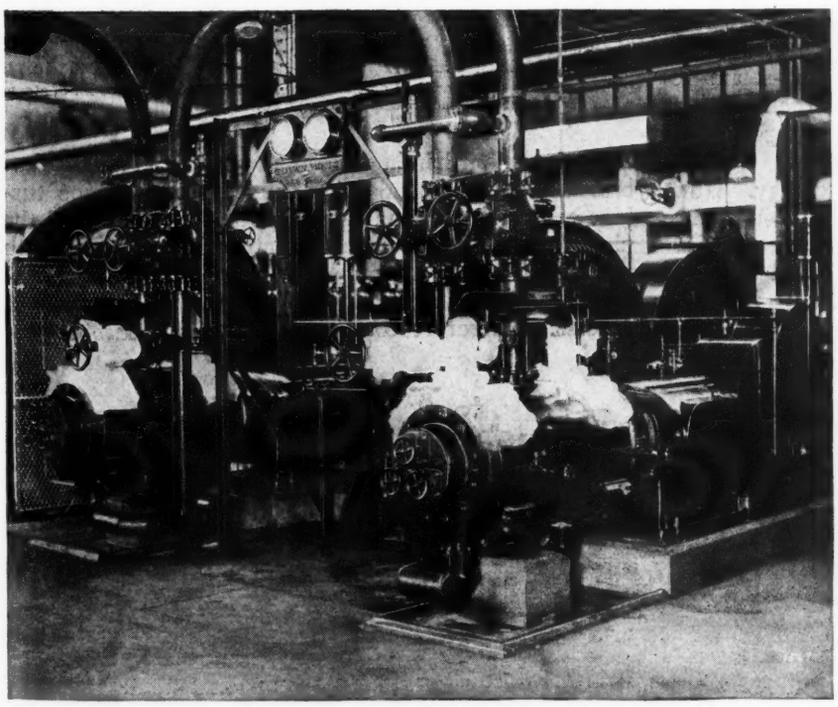


Fig. 2—Clearance pockets are used on the motor-driven compressors

Generated and Purchased

POWER BALANCED

on Cost Basis

Do you use a combination of purchased and home made power? If so, is the division of load based on a "hunch" or on a scientific cost analysis? Does your cost analysis clearly distinguish between variable and fixed costs?

By JOHN W. ROMIG
Mechanical Engineer
Corning Glass Works

AS A RULE modern industrial plants have enough generating capacity to provide current for at least essential parts of the load. Such equipment is usually designed so that exhaust from the prime mover provides steam for process and heating. In addition there is usually a purchased power supply to take care of remaining demands.

The equipment under consideration for energy cost comparisons in an industrial station includes boilers for the steam supply, a turbine-generator and auxiliaries of such design that it may be operated straight condensing, bleeding and, in some cases, as a mixed-flow unit.

This turbine-generator may be installed for protection of the plant or for supplying low-pressure steam or for both. During winter months when heating-steam requirements are large, or in cases where large quantities of process steam are needed, it is usually rightly conceded that a bleeding turbine will generate electrical energy at a price below that of purchased energy. However, during off-heating-season months the cost balance may favor purchased power if there is no use for low-pressure steam. Costs must be computed and the most economical scheme of operation determined.

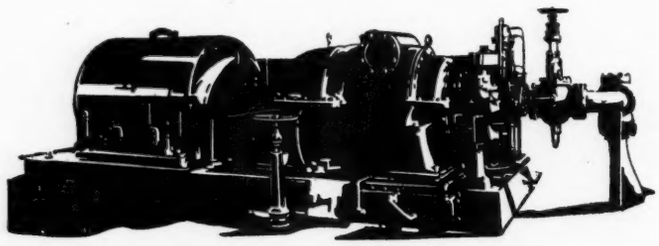
It is important to have an accurate record of water fed to the boilers or of steam generated, or both. If the quantity of water evaporated per month is not correct within 5 per cent plus or minus, conclusions must make allowance for error. Meters should be kept in good repair and checked frequently. Another consideration is the actual steam rate of the turbine-generator at various loads. If checks with accurate meters are made at three or four loadings and they compare closely with manufacturers' ratings, the manufacturers' curves may be safely used for all calculations involving steam rate. Usually steam rates given by builders are close to correct; however, blade erosion, inlet pressure, steam temperature, variations in vacuum from standard and other variables affect steam consumption. Such variations must be taken into consideration by actual checks with correct meters or weighing of condensate under varying load conditions.

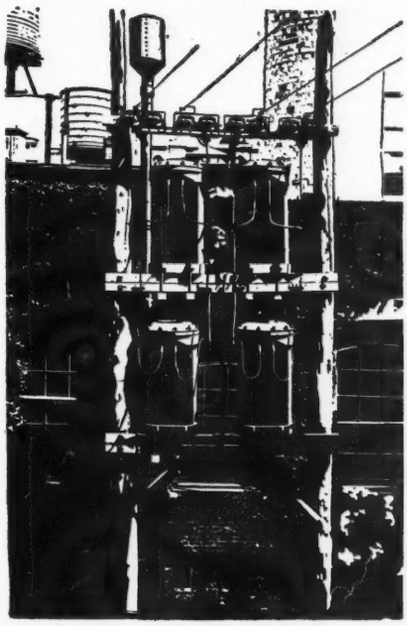
The method of approaching a problem of this sort is best explained by a practical example. The discussion and calculations herein cover the operation of a 1,000-kw. bleeding, straight-condensing, mixed-pressure type turbine-generator in an industrial plant. A portion of the plant load is considered as essential; interferences with the power supply over a very short interval will entail great loss because of lack of protection for materials in process. Therefore continuous use of the turbine-gen-

TABLE I—TOTAL STEAM COST

	Nov.	Dec.	Jan.	Feb.
Total cost boiler-room operation	$13,226.00	$13,882.00	$14,422.00	$12,242.00
Add fuel oil	500.00	500.00	500.00	500.00
Total	$13,726.00	$14,382.00	$14,922.00	$12,742.00
Net steam, 1,000 lb.	41,700	47,400	46,020	40,350
[1]Cost per 1,000 lb. of steam	$0.329	$0.303	$0.324	$0.316

[1]The average cost over the four month period is $0.318 per 1,000 lb. of steam when variable and overhead costs are combined.





erator is deemed necessary. The essential load, averaging 600 kw., is carried on the turbine, while the purchased-power load averages around 1,600 kw. Process-and-heating-steam requirements are low during the summer months, the low-pressure steam then required being furnished by other steam-driven equipment.

The problem of cost of generation at fractional loads together with the relative costs of generated and purchased power, provided the turbine is given additional load, arises for solution. Shall more or less power be generated?

Ample boiler capacity is available and held ready during seasons of high steam demand, and direct labor costs are constant throughout the year. Overhead charges, therefore, are not included in the steam cost used in comparing generated and purchased energy rates.

TABLE II—DETERMINATION OF VARIABLE COSTS

Time	Nov.	Dec.	Jan.	Feb.
Steam coal	$7,664	$8,271	$7,533	$7,255
Cleaning boilers	81	124	.....	.....
Boiler room repair and maintenance	452	540	732	739
Zeolite softener	481	554	549	805
Water	365	408	1,254	510
Fuel oil	500	500	500	500
Electric power	66	66	325	340
Steam	1,794	1,532	1,554	109
Total cost	$11,403	$11,995	$12,447	$10,258
Steam, 1,000 lb	43,839	49,920	48,390	42,561
1 95 per cent of steam	41,647	47,470	45,971	40,433
Variable cost steam per 1,000 lb	$0.274	$0.253	$0.270	$0.254

Average of four months cost is $0.263 per 1,000 lb. of steam

[1] Five per cent correction allowed for blowdown and correction to Venturi meter measuring feed water.

The proper steam cost, then, includes only those items which represent a day-to-day outlay of money—in short, the variable costs. They include water, fuel, power, repairs and supplies, these being the items that vary with the quantity of steam generated.

Table I shows the total steam costs over a period of four representative months and includes both variable and fixed costs. The item of $500 per month is added for fuel oil for emergency use during periods of stoker or other troubles that may cause low steam pressure. Total costs are useful when it is necessary to figure on additional steaming equipment. Costs for use in comparing purchased electrical energy with that generated by an existing installation must be based upon the variable costs alone. However, if additional equipment is needed, added carrying charges must be included for a true comparison. In the particular case here discussed no extra equipment was required, so additional carrying charges did not enter into the calculations.

Items making up the variable costs are shown in Table II. Some slight discrepancies in the data are due, in part, to a change in the method of distributing costs and in part to the method of operation. It was decided that the wiser course to follow in determining the steam cost was to accept the costs as shown on the records rather than making arbitrary adjustments.

The average variable steam cost of $0.263 per thousand pounds for the four representative months is the basis of steam cost in calculating generating costs. As the variable costs are almost proportional to the load, between limits 30 per cent above and 30 per cent below that of the four months investigated, the effect of load variations due to the operation of the turbine at partial or full load is negligible. In some cases this assumption cannot be made, especially where practically all of the steam generated is used for supplying a turbine generator under investigation.

TABLE III—STEAM AND POWER COST PER KILOWATT-HOUR TURBINE VARIABLE CHARGES

Load, Kw.	Auxil. Steam Lb. per Hr.[1]	Auxil. Kw. Hr[2]	Main Turb. Steam, Lb. per Hr.	Make up Water Turb. Cooling Tower, Gal.	Cost Repairs & Maint. and Oil per Hour[3]	Hourly Total Cost	Rate per Kw.
0	950	45	3,000	0	0	$1.535	Infinite
100	950	45	4,200	512	$0.022	1.912	$0.01912
200	950	64	5,400	1,030	.045	2.502	.01251
300	950	64	6,700	1,540	.068	2.906	.00968
400	950	64	7,900	2,050	.091	3.285	.00821
500	950	64	9,200	2,560	.114	3.694	.00738
600	950	83	10,400	3,080	.137	4.276	.00712
700	950	83	11,700	3,580	.160	4.682	.00667
800	950	83	13,000	4,100	.182	5.097	.00637
900	950	83	14,200	4,620	.205	5.467	.00607
1,000	950	83	15,500	5,130	.228	5.876	.00587
1,100	950	83	16,600	5,642	.251	6.234	.00566

[1] Condensate pump and steam air jet.

[2] Cooling tower fans, 19 kw.-hr. each; cir. pump, 16 kw.-hr. each; exciter, 10 kw.-hr. each—From 0 to 200 kw. rating one cooling tower fan is needed, from 200 kw. to 600 kw. two fans, and from 600 to 1,000 kw. three fans are needed.

[3] Repairs and maintenance assumed to be proportional to load and to be $2,000 per year at full 1,000 kw. load.

Note: A rate of $0.011 per kw.-hr. (average for the plant) is used in above calculations. This rate is high, but it places calculations on safe side. A water cost of $0.08 per 1,000 gal. is used for the cost of cooling tower make-up water while steam costs are based upon a cost of $0.263 per 1,000 pounds.

Steam, water, electric energy, repair, maintenance and oil costs of operating the turbine at various loadings are shown in Table III. From the total hourly operating cost the generating charge, including only the foregoing items, is developed. Rates are shown graphically in the chart by the curve marked "variable costs only."

An idea of total energy cost, including fixed and vari-

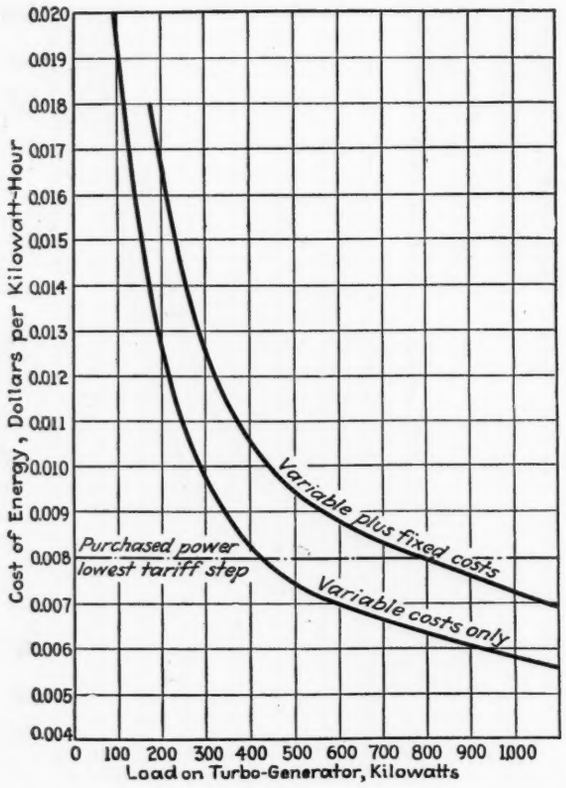
TABLE IV—TURBINE COSTS PER KILOWATT-HOUR

Fixed and Variable

Load, kw.	0	100	200	300	400	500	600	700	800	900	1,000	1,100
Steam per hr., lb.	3,950	5,150	6,350	7,650	8,850	10,150	11,350	12,650	13,950	15,150	16,450	17,550
Cost steam per hr.	$1.255	$1.639	$2.020	$2.450	$2.810	$3.225	$3.610	$4.020	$4.440	$4.920	$5.235	$5.575
Cost aux. elec. per hr.	0.495	0.495	0.705	0.705	0.705	0.705	0.912	0.912	0.912	0.912	0.912	0.912
Cost weater	0	0.041	0.082	0.123	0.164	0.205	0.247	0.286	0.328	0.370	0.411	0.451
Depr. cost per hr.	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459	0.459
Rep. maint. cost per hr.	0	0.022	0.045	0.068	0.091	0.114	0.137	0.160	0.182	0.205	0.228	0.251
Total cost per hr.	$2.209	$2.656	$3.311	$3.805	$4.229	$4.708	$5.365	$5.837	$6.321	$6.866	$7.245	$7.648
Rate per kw.-hr.	Infinite	.02656	.0165	.0126	.0105	.00941	.00894	.00834	.00790	.00762	.00724	.00694

able costs, is desirable, and Table IV is developed for this purpose. The analysis of total costs gives some idea of possibilities of competing with purchased power if additional turbine-generators are installed. Rates shown in Table IV are plotted in the curve marked "fixed plus variable costs."

A study of the curves shows that variable costs of generated energy equal the lowest tariff step of $0.008 per kilowatt hour when the unit operates at a rating of 425 kw.; at lower ratings the generating cost is greater,



Lower curve shows when it pays to operate existing equipment. Upper curve shows when new equipment would pay

while at higher ratings the generated cost is lower than purchased-power costs. It will therefore pay to operate the turbine at full load. At 800-kw. rating total costs are equal. If this rating could be maintained continuously additional generating capacity would compete with purchased power. However, the margin is too close as a load factor of 0.8 or greater is difficult to maintain in an industrial plant where the load is dependent upon fluctuations in manufacturing schedules. Therefore, justification of additional generating capacity must depend upon other circumstances.

The data here shown represent a set of actual conditions encountered in an industrial plant, and the method followed is, in general, applicable to any industrial station. Studies of this type should be made as often as fuel quality, fuel prices and purchased-power prices change. If a turbine is not operating under usual conditions as a result of blade erosion, changes in circulating water temperature, unclean water or other causes, and cannot be shut down for some weeks, a compilation of costs should be made. Studies of this type are well worth while from the viewpoint of economics, and are essential if intelligent control of power costs is to be maintained.

Through the Concrete in Twenty Minutes

FROM THE university comes a practical kink that will undoubtedly be new to most power men in the field. Putting a smooth round 8-in. hole through a concrete floor 9 in. thick would generally be looked upon as something of a chore. Yet this job can be completed in less than twenty minutes, according to Prof. F. V. Larkin, head of the department of mechanical engineering at Lehigh University. The *Power* editor who inspected a row of holes produced in the manner to be described can vouch for dimensions and high "quality" trueness. Professor Larkin, under whose direction the holes were drilled, is a reliable authority on the time requirements. Several of the holes, he said, were timed in less than twenty minutes each.

The machine used, with its student operator, is shown in the photo. It rotates a special type of core drill, similar in appearance to a piece of pipe with a diagonal slot at the end. The metal of this "drill" is ordinary soft steel. The actual cutting is done, not by the drill itself, but by chilled steel iron shot beneath the drill.

This machine, originally designed and manufactured to cut core samples from concrete highways, was brought to the floor-piercing job at Lehigh last summer to provide passages for a row of steam-engine exhaust pipes in the new million-dollar Packard engineering laboratory.

One of the stock objections to concrete construction has been the difficulty of making alterations. This kink makes the location and relocation of steam and exhaust pipes passing through concrete floors a relatively simple matter.

The only trouble with this method is that the job is too easy. One must avoid the temptation to drive through floors at points where electric conduits run, particularly when the cables are "live."

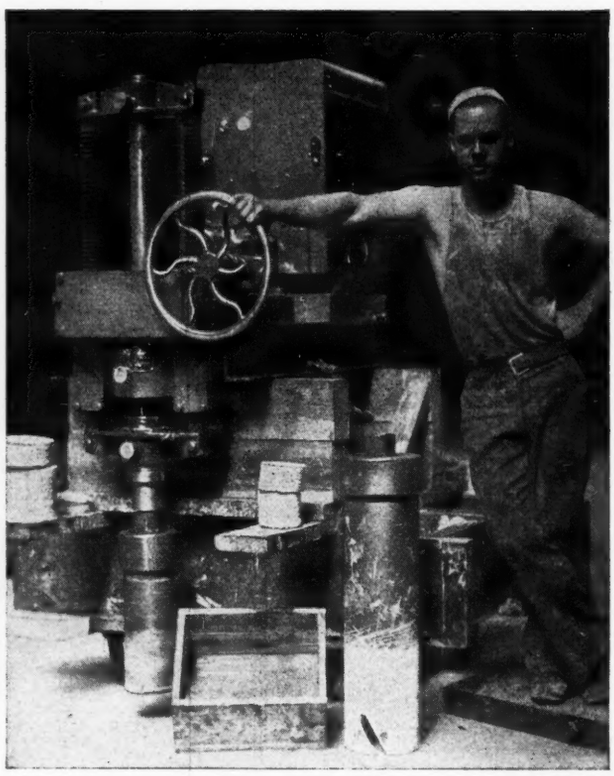


Chart Corrects Fuel Oil Volume

By Herbert S. Ender
Stationary Engineer in Charge
Municipal Building, Brooklyn, N. Y.

CONFUSION often arises over the question of the correct coefficient of expansion to use when correcting the volume of fuel oil at a given temperature to the volume at the standard temperature of 60 deg. F.

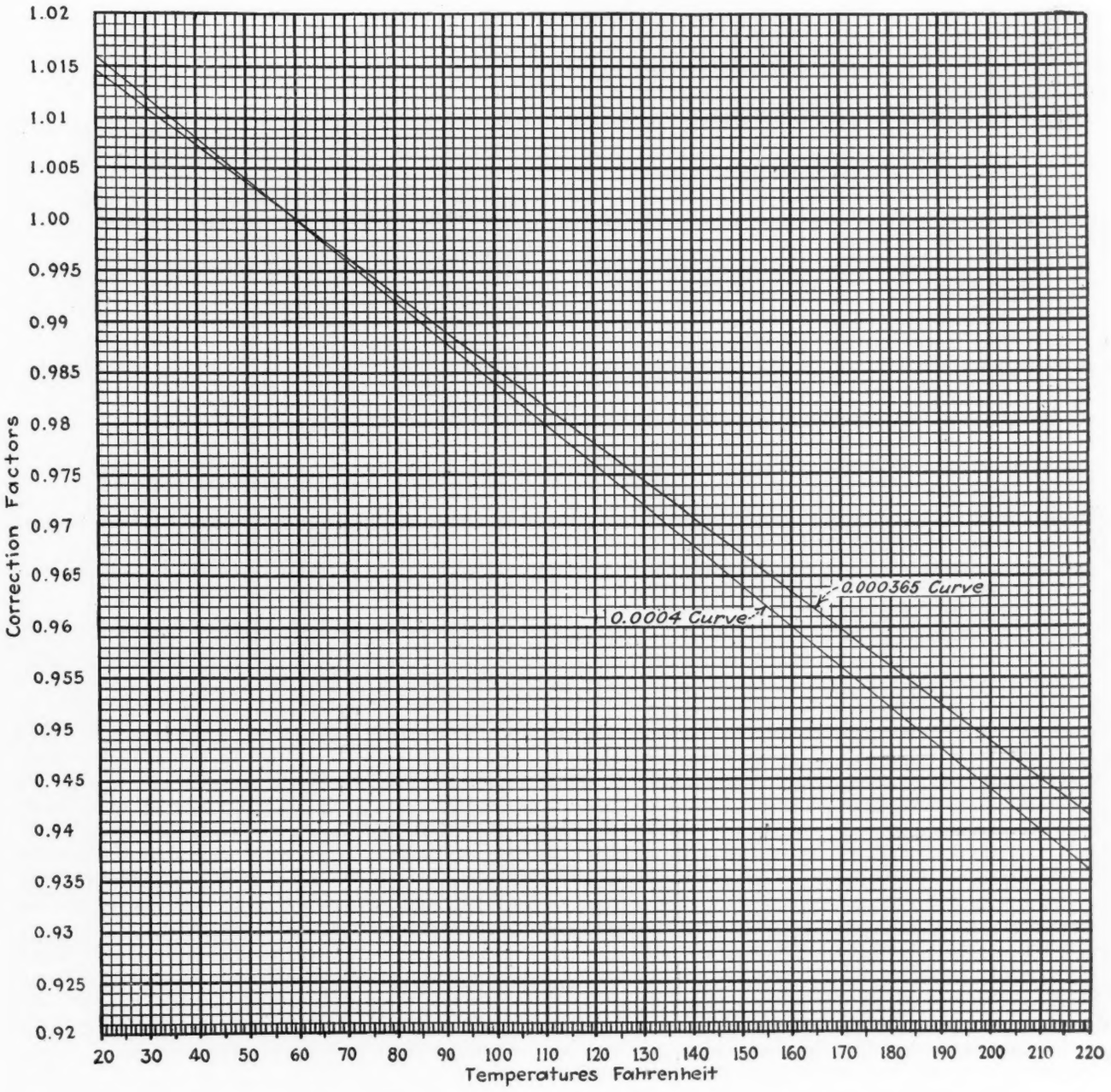
At present there seems to be no standard or universally adopted coefficient of expansion for fuel oil.

The contract for fuel oil where I am employed specifies 0.000365 as the coefficient to be used in determining the correct volume at 60 deg. F. In other positions I have had to use 0.00034 and 0.0004, and I believe that many other coefficients may be found among the oil-burning and Diesel plants in New York alone.

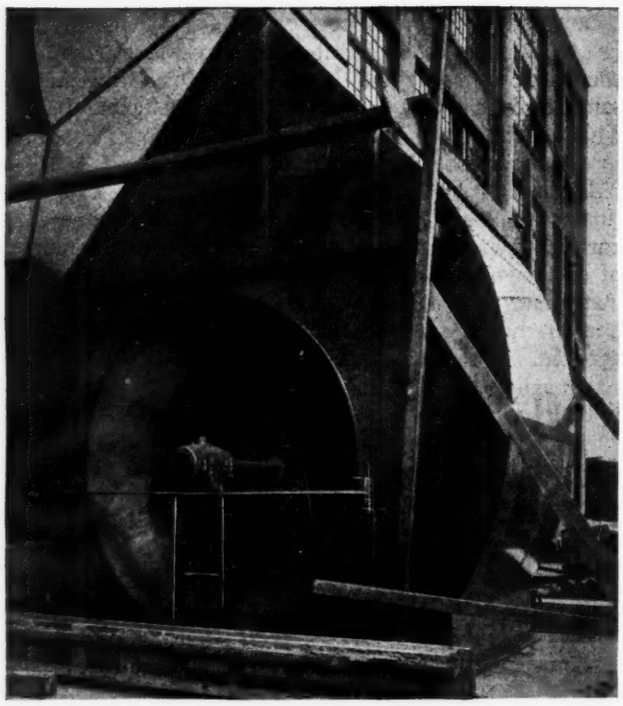
I have plotted a fuel-oil volume correction chart with a curve and factors for coefficient 0.000365 for my own use in this particular plant or in any plant where this coefficient is used, and have also incorporated in the same chart a curve and factors for coefficient 0.0004. This chart, as reproduced here, will, I hope, be of interest to some of the readers of *Power*.

Engineers using a coefficient other than the two mentioned can easily plot another curve on this same chart for their own particular use. However, with the number of coefficients now in use, a chart would have to contain many curves to serve all concerned, and it is my contention that a single coefficient can be, and should be, adopted, so that a chart with one curve would serve universally.

If I have given cause herein to open a debate among *Power's* readers, let the power men offer criticisms and tell us what pet coefficients they are using—and why.



Curves showing factors for correcting volume of fuel oil to volume at 60 deg. F. when using coefficient of expansion 0.000365 or 0.0004



One of the three 150,000 c.f.m. fans that supplies fresh air to a recent building of the Westinghouse Lamp Co.

Capitalizing the Employee's Comfort

By R. W. Pryor

MANY MANUFACTURERS are confronted with a problem of mechanical ventilation, which directly involves the comfort of the operator, and indirectly the labor turnover. One of the first questions to be asked by the management in considering the installation of ventilating or air-conditioning equipment is, "To what account should the cost of this investment be charged?" Relatively, these installations seem to be excessive in cost, largely because of the seemingly intangible results derived from such expenditure.

Air-washing equipment installed in one of the buildings of the Bloomfield plant of the Westinghouse Lamp Company has definitely decreased labor turnover, speeded up production, and increased employee efficiency by the elimination of fatigue due to excessive heat and vitiated air. This manufacturer, looking upon such an investment in terms of increased production, found that the capital invested in such a system paid for itself during the first season's operation; principally due to the fact that a shutdown during the hot dry period of early July, 1929, was avoided.

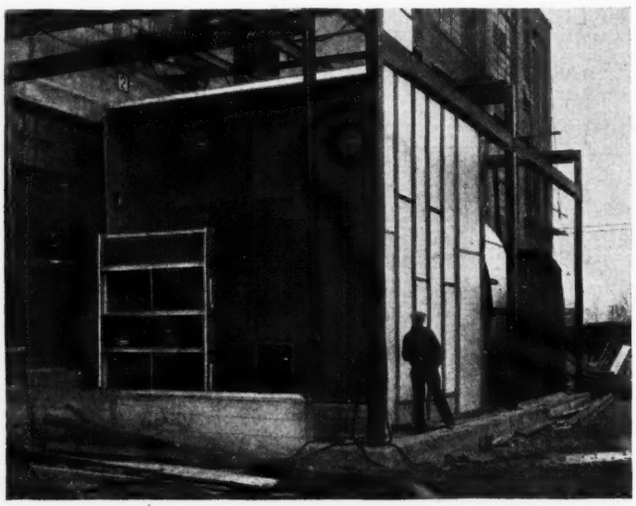
The building served by the ventilating equipment has a superficial floor area of 126,000 sq.ft., and a cubical content of 2,020,000 cu.ft. There are approximately 2,500 employees engaged in the various operations of lamp manufacture.

Heat generated by gas flames used in the manufacturing process produces a heat saturation of approximately 250 B.t.u. per hour per square foot of floor area. Removal of this quantity of heat is accomplished by a scavenging system of ventilation, which supplies the building with 27,000,000 cu.ft. of fresh washed air per hour. This quantity of air is supplied by three fans, each belt-driven by a 75-hp. motor, one of which is shown in the illustration.

Each fan is served by a two-stage air washer in which 1,150 gal. of water per minute is sprayed by a 5-in. centrifugal pump. The air washers are capable of reducing the temperature of the air passing through them by an amount equal to 95 per cent of the difference between the wet and dry temperatures of the atmosphere.

Each air washer and 150,000 c.f.m. fan form a unit that is housed outside of the main building. The fans discharge into outside vertical ducts from which the fresh washed air is delivered to main supply ducts at the ceiling of each of the three floors. No interconnection has been made between the three units, each supplying air to about one-third of the building.

Fresh air is introduced near the floor line through open ends of branch ducts at low velocities that do not interfere with the gas flames used in lamp manufacture. In this manner the entire floor is practically alive with an upward current of washed air that rises through the breathing zone and pushes before it the heat and noxious vapors to the ceiling. No attempt is made in this scavenging system to take advantage of mixing air of different temperature and calculating for a heat balance, for the reason of limitations of manufacturing.



The air washer and tempering stacks during construction

At the ceiling line there is an equal amount of exhaust fan capacity. On the top floor of the building propeller-type fans are in penthouses on the roof. On the lower floors the fans are in the upper part of the windows, with suction ducts extending back to the center of the floor area. There are approximately 50 of these units. The scavenging system has proved particularly effective and does not subject the operator to any objectionable draft or extreme temperature differences.

Before cold weather sets in the 75-hp. motors driving the fans are replaced by smaller, lower-speed motors, and the system is operated at reduced capacity. Air is tempered by extended surface heaters before it enters the building.

There is every reason to believe that the ventilating system has considerably reduced the labor turnover, and it is estimated that this cost has been decreased at least 10 per cent.

Color Code for Piping

By J. Elmer Housley
Superintendent, Tallassee Power Company, Tapoco, N. C.

PIPING constitutes the arteries of the power house. Its identification is vital for convenience and safety in the operation and maintenance of the plant. Piping arrangements cannot be made fool-proof against improper operation, but such events occur more often because of confusion than for any other reason. Simplicity of operation can best be attained by the use of striking colors for the service pipes. Daily contact with the distinguishing marks gives the attendants confidence in operation not attainable otherwise.

Color-code painting adds a measure of attractiveness to the plant, and the effect of color is harmonious. Protection of the metal of the pipe against corrosion is gained by keeping the surface properly painted. Scratches, abrasions and discolorations should be watched in the interest of protection and good housekeeping.

The schedule of painting for piping in hydro-electric power houses adopted by one company is shown in the diagram. The chart may be made in the form of a blueprint and framed for posting in the plant. In some plants a large bulletin board is preferred, with the colors blocked in alongside the legend. Either method provides a handy reference and may be used to instruct new operators or repairmen concerning the color code and the piping arrangement.

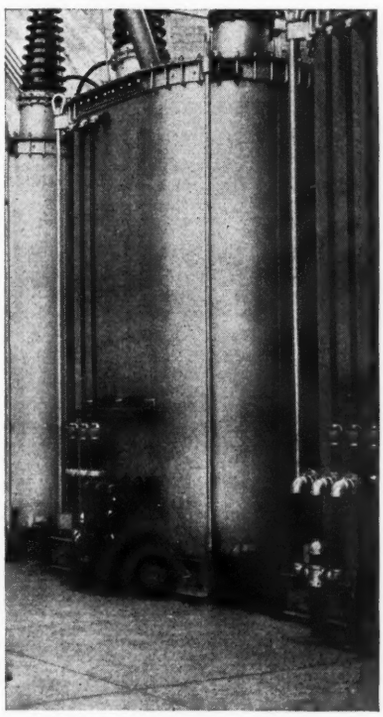
Water pipes in plants supplied from a source of cold water sweat during the spring, summer and fall seasons when the temperature of the pipe is below the dew point of the air. These pipes must be covered with an anti-sweat insulation which is jacketed with cheese cloth or light canvas and banded with metal straps. Before painting with the colored paint, the cloth must be treated with a prepared sizing or with aluminum paint, using a spar varnish vehicle. All wrought-steel pipe should be given an initial coat of red lead or other rust inhibitive to prevent corrosion under the paint film.

Sample Color	Contents of Pipes	Sample Color	Contents of Pipes
Moss Green	Water Pipes, *Pressure*	Dark Brown With Red Fittings	Governor Pipes, *Return and interconnecting lines at low pressure*
Moss Green With White Fittings	Water Pipes, *Return*	Black	Governor Pipes, *Oil or water drain lines into sump or tail race*
Yellow	Lubricating-Oil Pipes, *Pressure*	Red	Gasoline Pipes
Yellow With Red Fittings	Lubricating-Oil Pipes, *Return*	Maroon	Air Pipes, *Pressure*
Buff	Transformer-Oil Pipes, *Pressure*	Aluminum	Conduit Pipes
Buff With Red Fittings	Transformer-Oil Pipes, *Return*	Gray	Exhaust Pipes, Air or Gas
Dark Brown	Governor Pipes, *Pressure*	Same as Walls	Roof Drains

Schedule of painting for piping of the Tallassee Power Company

In the schedule given all pressure pipes are painted in solid color on the pipe and fittings alike. For the return line of each service the same body color is used on the pipe and the fittings are painted with a contrasting color to command attention.

Satisfactory appearance is obtained by painting all electrical conduits with aluminum paint. The pipe supports for switchboards and the framework for electrical apparatus are also given this color, for distinction as well as appearance.



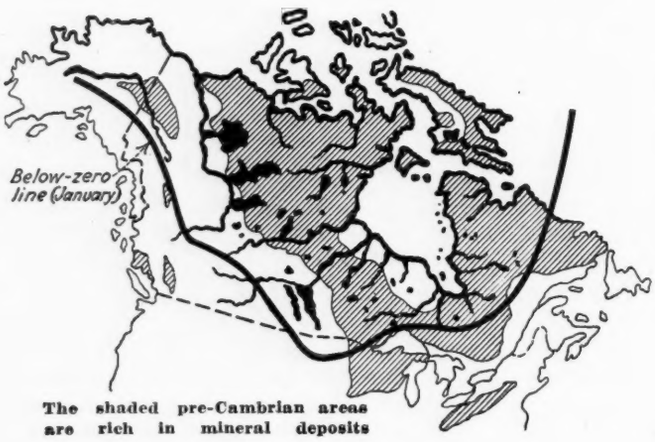
All pressure pipes are painted one color, but the return lines have fittings of contrasting colors

Correcting Power Factor With Rotary Converters

THE QUESTION of how much power factor correcting can be done with a synchronous converter is one about which there has been considerable discussion and difference of opinion. A thing frequently overlooked is that the conditions in the machine change with load. When the rotary is supplying direct current, the current that causes heating of the armature coils is a combination of the alternating-current input and the direct-current output. This causes the tap coils in the armature to heat more than the others and limits the current that can flow without overheating the winding.

When the machine is operating at no load it becomes a synchronous motor and the current is equally distributed in the windings. Under this condition the machine can be operated at a leading power factor in much the same way that a unity-power synchronous motor may be at light loads. The limiting factor in this case will be the field current, and will be determined by the safe field-coil temperature. At full load the machine should operate at near unity power factor. However, it will probably correct the power factor of the systems more than when operating lightly loaded at leading power factor. At intermediate loads, the limit of leading power factor that the machine can operate at without overheating will depend to a degree upon its design. As a general proposition it may be stated that at 50 per cent load the power factor can be made about 60 per cent leading.

Extracting HEAT and POWER from ICE WATER



The shaded pre-Cambrian areas are rich in mineral deposits

A decidedly novel scheme for utilizing the heat in Arctic lakes and rivers is proposed by Dr. H. Barjot of Montreal, Canada. Ice water is used as "fuel" to vaporize a hydro-carbon. The vapor after passing through a turbine is condensed by blocks of frozen brine.

A FEW years ago the French scientist Claude created a sensation by proposing to harness the heat in the surface waters of tropic seas for the production of power. In Claude's scheme low-pressure vapor from the upper ocean layers is passed through a steam turbine and condensed with cooler water from great depths. Claude's proposal has proved to be mechanically workable on a laboratory scale, although many engineers do not accept it as economically sound, because of the enormous size of turbine required to handle the low-pressure vapor, the small temperature-drop, pumping complications and other practical difficulties.

Now comes a still greater surprise. It is seriously proposed that the *heat* in ice water be used to make power. Doctor Barjot, H.M.R., of Montreal, doubtless inspired by the rigorous winters of his home town, has developed a plan for utilizing the vast stores of heat in the ice water underlying Northern ice packs such as are found in the Arctic lakes and rivers surrounding Hudson Bay.

Without passing upon the economic feasibility of such a plan, *Power* considers it of sufficient scientific interest to justify a brief explanation. The following description and comments are based on information supplied by Doctor Barjot, and are presented as representing his point of view only.

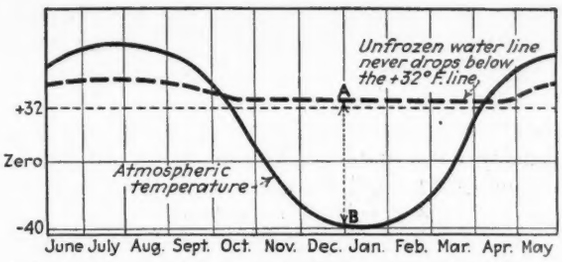
His plan, in brief, is to use the supply of ice water to vaporize a special hydrocarbon of suitable boiling point. Vapor thus produced is to be passed through a turbine and condensed in a tank containing blocks of frozen concentrated brine ("cryohydrate"). These blocks, prepared by exposing the brine in open channels above the ice pack, would have, according to Doctor Jarjot, a temperature around —6 deg. F. This gives a total available temperature drop of 38 deg. F. from water at 32 deg. The condensing material—cryohydrate —is so cold that the ice water is hot by comparison and can serve as a source of heat.

Before going further into the details of the proposed plan and its operation, it will be worth-while to present some of the data prepared by Doctor Barjot to indicate the economic field for this method of power generation.

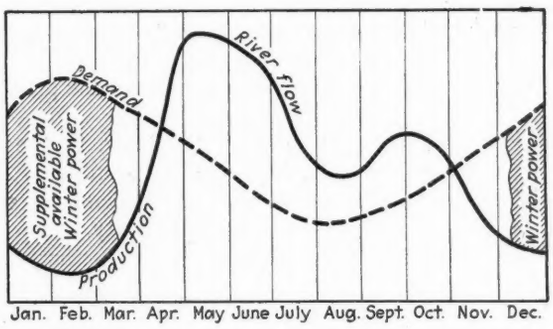
The map shows the romantic and largely uninhabited region surrounding Hudson Bay. Often referred to as the Laurentian Plateau region, the shaded area is a huge stretch of precambrian rocks believed to cover two million square miles. Its western end extends across northern Manitoba and Saskatchewan up to Alaska.

The precambrian rocks are full of a variety of mineral deposits: iron, copper, nickel, silver, gold, platinum. To work the mines and deposits that will eventually be opened in this region, power will be required. One might judge from a glance at the map that potential water power is available, since the region is covered with a network of large rivers apparently suitable for hydro development. However, while large water-power capacity would be "on tap" in the summer time, the climate would, according to Doctor Barjot, practically prevent its generation in the winter.

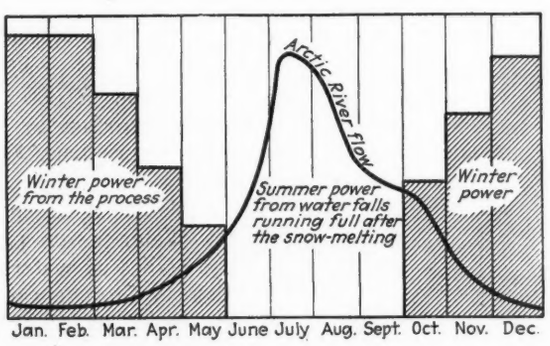
The winter cold of these regions is properly termed "brutal." No part of the entire area bounded on the south by the heavy isothermal line in Fig. 1 has an



Seasonal variation of atmospheric and water temperatures in the Arctic. AB shows the mid-winter temperature difference available for power production



Typical Canadian river-flow curves show deficit of available water power in winter months


Arctic River Flow
Winter power from the process
Summer power from water falls running full after the snow-melting
Winter power
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Curve for a river in the far north (Mackensie) shows impossibility of developing much water power in the winter months

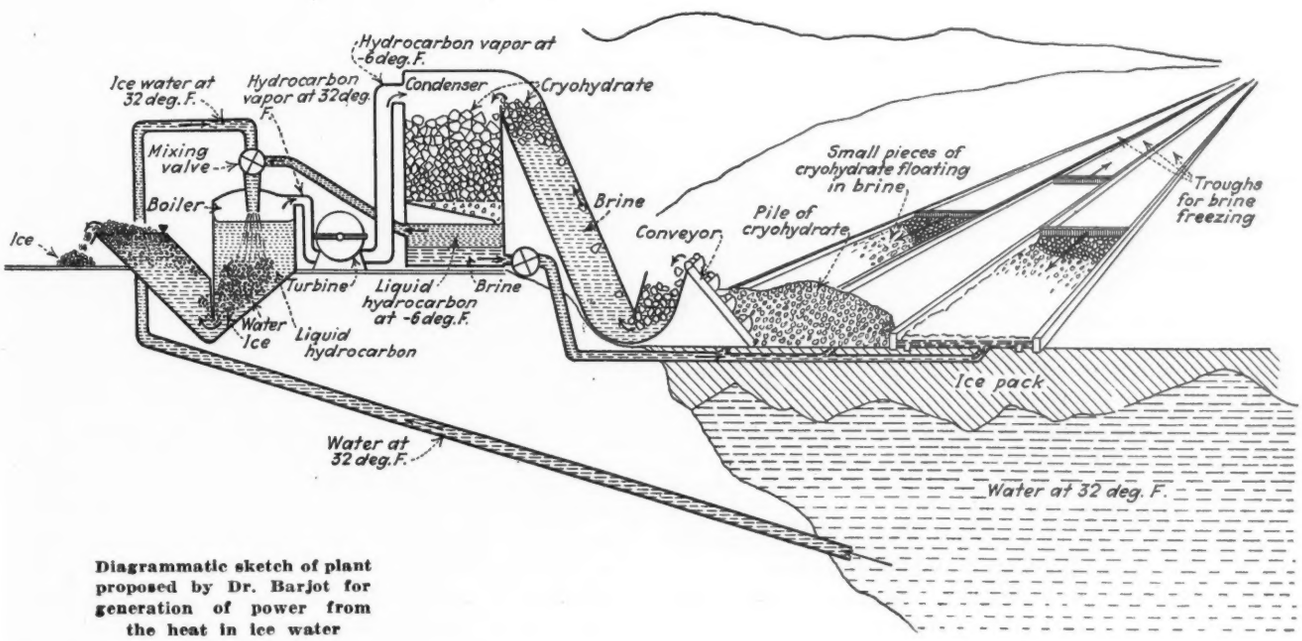
average January temperature above zero. The winter cold even along the southwestern shore of Hudson Bay approaches that of polar regions.

This cold, Doctor Barjot points out, is significant in two ways. First, as shown in the charts, it reduces stream flow to a point where little water power can be obtained. This obviously calls for a supplementary source of power for winter, and here Doctor Barjot is able to point out that the peak availability of his system will occur when stream flow, and hence, available water power, is lowest.

With this justification for the study of a very interesting scientific proposal, we may return to the consideration of the Barjot plant. One possible form, by no means the only one suggested, is shown below. This, of course, is purely schematic. At the right is the ice pack floating on water at 32 deg. F. Troughs of great area are formed on top of the ice pack to hold and freeze the brine. The method of obtaining the original supply of brine will be discussed later. As the brine freezes, it is collected in small chunks by special moving screens, or "rakes," and delivered to a storage pile or directly to the inside of the condenser. The method shown for getting the blocks of cryohydrate into the condenser without breaking the seal may be modified as shown on the next page.

Turning now to the source of heat, the "fuel" supply —water at 32 deg.—is drawn from beneath the ice pack and passed through a mixing valve, where it is brought into intimate contact with the liquid hydrocarbon pumped back from the condenser. Most of the "boiling" takes place in this valve, the water giving up the latent heat of ice in freezing, while the hydrocarbon absorbs the latent heat of vaporization in boiling. The "boiler," which, by the way, operates at a pressure below atmospheric, is partly full of liquid hydrocarbon and is provided with a seal through which the ice that is formed may be removed, as shown.

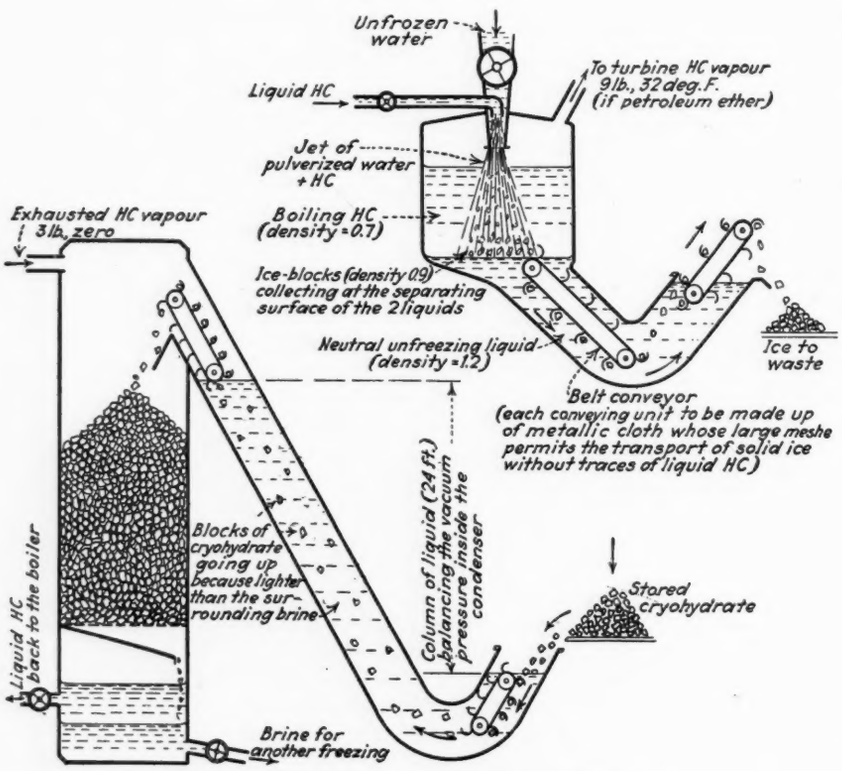
The intimate mixing makes possible heat transfer with little temperature drop, so that the hydrocarbon vapor is at a temperature but little below 32 deg. when it passes to the turbine. Similarly, direct contact of fluid and cryohydrate blocks in the condenser reduces



Diagrammatic sketch of plant proposed by Dr. Barjot for generation of power from the heat in ice water

the necessary temperature difference, so that the vapor cools nearly to —6 deg. F. The condensate trickles down to the base of the condenser, where it floats on the heavier brine. Not only are the brine and hydrocarbon distinctly different in weight, but they are mutually insoluble; so the problem of separation is simple. Brine from the bottom of the condenser is piped back to the troughs on the ice pack for refreezing.

Doctor Barjot contemplates using a petroleum byproduct with an absolute pressure of one atmosphere or less at 32 deg., which can be expanded down to one-third or one-fifth atmosphere at condenser temperature. Such


Unfrozen water
Liquid HC
To turbine HC vapour 9 lb., 32 deg. F. (if petroleum ether)
Jet of pulverized water + HC
Exhausted HC vapour 3 lb., zero
Boiling HC (density = 0.7)
Ice-blocks (density 0.9) collecting at the separating surface of the 2 liquids
Neutral unfreezing liquid (density = 1.2)
Ice to waste
Belt conveyor (each conveying unit to be made up of metallic cloth whose large meshe permits the transport of solid ice without traces of liquid HC)
Column of liquid (24 ft.) balancing the vacuum pressure inside the condenser
Blocks of cryohydrate going up because lighter than the surrounding brine
Liquid HC back to the boiler
Stored cryohydrate
Brine for another freezing

Alternate methods of operating condenser (left) and "boiler" (right)

fluids as butane and propane, gases at ordinary temperatures, have been considered.

In the "boiler" it is planned to remove the water and ice mixture when about 50 per cent is converted into ice blocks, the final mixture thus remaining "liquid" for easy handling and removal. The turbine involves no difficulties in design or construction, being merely an adaptation of the ordinary steam turbine.

A supply of concentrated brine with a melting point as low as —6 deg. F. can be made by repeated freezing of sea water. Plants erected on the shore of Hudson Bay or the Arctic sea may thus concentrate the available water. Sea water in freezing gives pure ice crystals, which separate and leave the remaining liquid a more concentrated salt solution. In a few steps any desired concentration is easily obtained.

Doctor Barjot estimates that a square mile of brine frozen to a depth of 6 in. will give a 24-hr. supply of cryohydrate to the condenser of a 75,000-hp. plant working continuously at full load.

A study of this proposed plant shows how arbitrary are some of the distinctions necessary in ordinary power plant operation. With the usual condensing steam plant the cost of fuel is many times that of condensing water. We naturally, therefore, express the performance in terms of pounds of fuel consumed per kilowatt-hour.

If, however, condensing water were necessary in all cases, and its cost were far more than that of the fuel, we would naturally rate plants in terms of quantity of condensing water used per kilowatt-hour produced.

An analagous condition exists with the Barjot plant. It is evident that the weight of water frozen in the boiler would be approximately equal to that of the cryohydrate melted in the condenser. The cryohydrate would cost more, because great exposure areas would have to be prepared and provision made for harvesting the blocks. Thus, as far as operating costs are concerned, the condensing medium rather than the fuel becomes the determining factor, although the latter would involve a considerable pumping charge.

By thinning the brine in the late winter, it would be possible to continue operation of the plant for some weeks at reduced capacity.

Doctor Barjot believes that direct contact of vapor with the freezing blocks in the condensate will give far more effective heat transfer than that obtained in any device employing tubes. A tower 40 ft. high, 10 ft. in diameter filled to 75 per cent of its capacity with cryohydrate blocks of 8 cu.in. average size would provide a contact surface exceeding 80,000 sq.ft. To obtain an equal surface in 1-in. tubes would require more than 300,000 lineal feet.

Steam-power plants store energy in coal piles. Water-power plants store it in huge bodies of water impounded by dams. Storage can be applied in the Barjot plant, but to the heat-absorbing substance rather than the "fuel," the latter always being available in sufficient quantities. Cryohydrate frozen during the cold nights can be stored in piles to carry the peak loads of the day.

As has already been pointed out, the information given in this article has been paraphrased and rearranged by the editor from material supplied by Doctor Barjot. Much of the data given cannot be conveniently checked, and there is, of course, great room for difference of opinion on the matters of cost, commercial feasibility, etc. Doctor Barjot, for example, says that a large plant built according to his system could be erected for about $15 per horsepower. While it might be expected that the cost of such a plant would be very low, barring high construction costs associated with cold, inaccessable locations, the figure given is hard to reconcile with the present cost of large turbines alone. Surely some substantial investment must be made in the boiling and condensing equipment, in pumps and piping and in extensive equipment for harvesting the cryohydrate, although this investment is not easy to estimate.

However, from a scientific point of view, few proposals in power history have been more interesting than that of Doctor Barjot. It has at least the merit of not violating any known laws of mechanics or thermodynamics and of being conceivable as a working plan.

...RIGHT OUT OF THE PLANT...

What Recirculation Accomplishes

WHILE the practice of recirculating boiler water to the water softener is increasingly used and with excellent results, the process is still widely misunderstood. For this reason the writer feels that many *Power* readers will be interested in the following discussion.

In hot-process treatment, the most complete removal of "hardness" is accomplished by maintaining the maximum feasible excess of soda alkalinity in the treatment tank. This principle is generally known and is recognized in the A.S.M.E. boiler code by recommendation of a minimum of 1.5 grains per gallon (Par. CA-13), but in its application due consideration must be given to various factors.

With ordinary blowdown practice, a high soda alkalinity in the reaction tank will lead to an unduly high boiler alkalinity, which when exceeding the allowable limit for the particular condition will interfere with the quality of the steam. A high rate of blowdown can be made to compensate for the consequences of a high soda excess in the treating process, but only with sacrifice of economy.

Another limiting factor in ordinary blowdown practice is the ratio of the soda alkalinity to the sulphates present. It remains constant in treatment tank and boiler. In the range of boiler pressures in common use, it is now generally recommended that the ratio of sodium sulphate to total alkalinity be not less than 3 to 1. To maintain that relation in the boiler it is necessary to keep the same ratio in the treatment tank, so that any large excess soda alkalinity in the latter will call for a correspondingly high amount of sulphates.

While a minimum of 1.5 grains per gallon excess soda alkalinity is essential for even a reasonably low residual hardness, an excess of 2½ to 3 grains per gallon is very desirable, and with it an extremely low residual hardness can be obtained.

By recirculating a small part of the boiler water to the treatment tank the following favorable conditions are produced in the tank and boilers.

Alkalinity can be maintained at any desired point independent of the amount discharged to the sewer (blowdown).

The boiler water returned to the tank supplies the latter with a large excess of sodium carbonate, essential to the production of a water low in residual hardness.

As sulphates brought to the system by the raw water or by the addition of sulphate salts are eliminated only by the "blowdown," concentration of this constituent can be regulated to produce any value desired.

The quantity of suspended solids in the boiler is a function of the amount of water withdrawn from the boiler. In a process which recirculates a part of the boiler water the amount of water withdrawn from the boiler equals that "recirculated" plus the "blowdown."

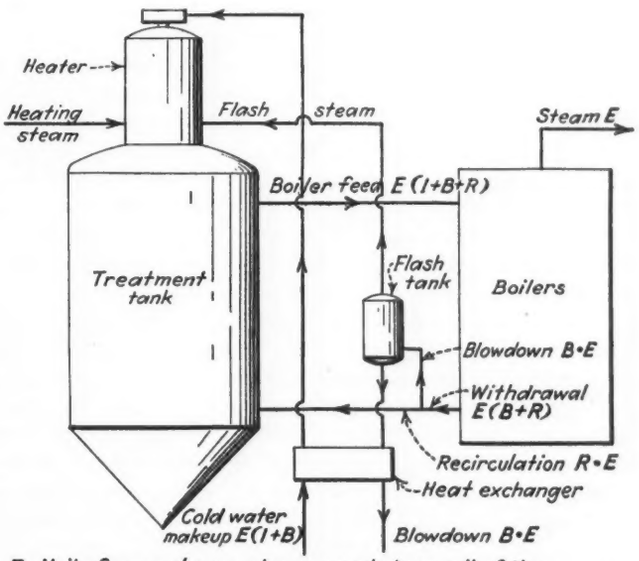
The boiler water brings to the treatment tank a small amount of caustic, obtained from the dissociation of sodium carbonate within the boiler. The value of this caustic is definite, but incidental to the process.

The large excess amount of normal sodium carbonate introduced into the treatment tank, with its tendency to take up the bicarbonate radical rather than the calcium and magnesium, decreases the requirement of hydroxyl radical in the process; or allows a greater range between that required to produce a low residual hardness and that which will give an excess of free caustic in the treated water.

Recirculation acts to reduce the proportion of free caustic in the boiler by causing a lower dissociation of the sodium carbonate. This is a most desirable feature in protection from embrittlement, and gives greater assurance of precipitation of any residual hardness as a sludge.

With recirculation the tank and boilers may be considered a single system. The large amount of soda alkalinity existing in the boilers is a reserve that will supply the treatment tank during any irregularities of chemical feed. The large excess of this reagent in the tank also assists in tiding over an interruption of the feed of new chemical. Under no circumstances can recirculation increase the concentration of any undesirable salt within the boiler.

The following relations exist between the flow of



E = Unit of raw makeup water evaporated per unit of time
B•E = Amount of water discharged to sewer over same time
R•E = Amount of water recirculated to tank over same time
C_r, C_t and C_b = Concentration of any given constituent in raw, treated and boiler waters respectively

Illustrating relation between blowdown, recirculation and concentrations

water in the treatment tank and boilers. (Refer to diagram.)

Amount of any given salt fed to boilers = amount of same salt withdrawn.

$$E\ (1 + B + R)\ Ct = E\ (B + R)\ Cb$$

or

$$(1 + B + R)\ Ct = (B + R)\ Cb \qquad (1)$$

Since treating tank and boilers may be considered as one system, the following holds for any soluble salts as sulphates, chlorides, etc:

$$(1 + B)\ Cr = (B)\ Cb \qquad (2)$$

Example:

Raw water of the following analysis:

	Parts per Million
Total hardness as $CaCO_3$	129
Calcium hardness as $CaCO_3$	93
Magnesium hardness as $CaCO_3$	36
Alkalinity as $CaCO_3$	104
Chlorides as NaCl	27
Sulphates as Na_2SO_4	53.5
Silicates as SiO_2	8
Iron, etc., as R_2O_3	10

Assume:

A minimum of 25 parts per million excess sodium carbonate in treatment tank. Boiler alkalinity of 500 parts per million is desired. Sulphate to carbonate ratio of 3:1.

The following conditions would prevail in the tank and boilers—applying Formulas 1 and 2.

With Recirculation	*Without Circulation*
B = 0.037 or 3.7 per cent	B = 0.527 or 5.27 per cent
R = 0.074 or 7.4 per cent	

TREATED WATER

	Parts per Million	Parts per Million
Na_2CO_3	50	25
Na_2SO_4	150	75
NaCl	76	27
Residual hardness	17	34

BOILER WATER

	Parts per Million	Parts per Million
M. O. alkalinity	500	500
Na_2SO_4	1,500	1,500
NaCl	760	540
Suspended matter	170	680
Total solids	2,930	3,220

With recirculation the treating excess is 50 parts per million Na_2CO_3 as against 25 parts per million without recirculation; the blowdown is only 3.7 per cent, as against 5.27 per cent, and still the boiler alkalinity is the same in both cases.

It is an established fact that higher excess of Na_2CO_3 will result in lower residual hardness. Lower residual hardness means that fewer solids will be precipitated in the boilers, and due to the higher withdrawal—11.1 per cent as against 5.27 per cent—the amount of suspended matter in the boiler water is still further reduced. The result is that the total solids in the boiler water are lower with recirculation than without, although the actual blowdown is less.

The amount of soda ash required for precipitation of the permanent hardness is, of course, the same with either method of treatment. However, when the excess to be supplied without recirculation is 25 parts per million of sodium carbonate, with recirculation there is required only 18.5 parts per million. Furthermore, without recirculation there has to be supplied 75 — 53.5 = 21.5 parts per million Na_2SO_4, while with recirculation the necessity of adding sulphates is eliminated, as is clearly shown by applying Equation 2 using the established value for B. It naturally follows that operation of the treating system is greatly simplified by elimination of the sulphate feed. The efficiency of the process is the most important factor; the saving in cost of chemicals is only incidental. However, that saving is large enough to more than offset the cost of recirculation.

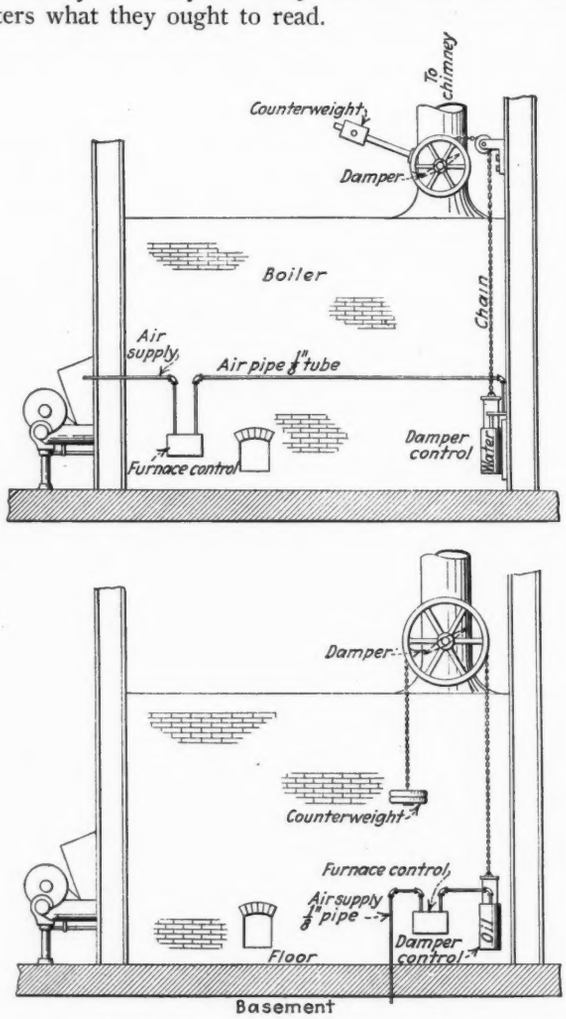
If an excess of 50 parts per million of sodium carbonate can be carried in the treated water, any irregularities in the chemical feed will be readily absorbed without materially affecting the results of the treating process. When operating at the minimum value of 25 parts per million, as is necessary when no recirculation is applied, the system becomes much more sensitive, and undertreating is apt to occur.

The process, as patented, permits selection of the reagent or reagents best suited to meet the conditions in each individual case and is not limited to any specific chemical.

P. M. CONTANT,
Chief Engineer,
Neckar Water Softener Corp.
New York City.

How the Operation of Balanced-Draft Control Was Materially Improved

WE RECENTLY made some changes in the arrangement of our balanced-draft equipment which have materially reduced the attention required and improved the operation. As the control was originally installed (shown in the upper view), we had to adjust some parts of it every few days to keep the air-flow steam-flow meters what they ought to read.



Original and present arrangement of the balanced-draft equipment

Before the change the damper shaft bearings were built in the sides of the uptake. In this position they were always hot and could not be lubricated. To reduce the friction at this point the shaft was made longer and fitted with roller bearings placed away from the heat where they could be properly lubricated. The pulley on the damper shaft was also increased from 18 in. to 30 in. This change, in addition to reducing friction on the damper shaft, made it possible to reduce the air pressure from 20 to less than 10 lb. We also changed from water to oil in the damper control and relocated the furnace control as near to the damper control as possible, so that the latter would respond more quickly to any changes in the furnace or combustion chamber conditions.

Since these changes we can average 0.05 to 0.08 in. overfire draft with 150 per cent rating on the boiler. We add a little oil to the damper control twice a week. Two of the controls have been in operation over three months without giving any trouble. The control on the third boiler will be changed in the same way except that ball bearings will be used on the damper shaft instead of roller bearings. JOHN C. CASLER, *Chief Engineer*,
Winchester, Mass. Beggs & Cobb.

Can a CO_2 Record Indicate a Cracked Baffle?

THE BELIEF seems to exist with some engineers that if there is a leak through a boiler baffle a CO_2 recorder will unfailingly reveal it. While it is quite possible for a CO_2 recorder to indicate a leak, the indication is not necessarily reliable. It all depends upon conditions. In the event of an excessive leak through a baffle combustion might even occur in the stack itself in a position past the point of gas sampling, in which event the CO_2 reading should be of considerable value.

Assuming that the furnace is large enough, after the gases once pass into the tube bank there will be no more combustion, and the percentage of CO_2 from that point on is the same as in the stack. Therefore a broken baffle will make no difference in a boiler of correct design as regards CO_2 reading.

But a broken baffle can make a surprisingly big difference in the efficiency of a boiler. If hot gases are permitted to leak through a broken baffle the exit-flue-gas temperature will be unusually high. Less heat will be absorbed by the tubes. The temperature of the stack gases will indicate the seriousness of the leak. The best way to detect a broken baffle, then is with a thermometer or temperature recorder in the stack or breeching.

Nearly all of the gases could pass directly from the furnace into the stack and yet a CO_2 recorder might indicate that combustion is efficient. But the boiler would not be efficient, owing to the high temperature of the exit gases. A pyrometer or flue-gas thermometer would soon show something wrong.

On important boilers it is advisable to employ both a CO_2 recorder and a temperature recorder. Or, be certain that the quantity of air in proportion to the amount of fuel burned and the amount of steam produced is correct. If fuel, steam, air, volume of furnace, and temperature of flue gases are right, you can be reasonably sure that there are no cracks in the baffles.

Newark, N. J. W. F. SCHAPHORST.

Using Heavy Oil in Diesel Engines

IN THE Feb. 4 number of *Power* there were discussions as to the style of Diesel engine, solid- or air-injection, most suitable for an installation where the oil was to be 18 to 22 deg. Baumé. Experience in the plant of which I am in charge seems to answer this question practically and without speculation as to results.

Our plant consists of two 135-hp. engines of the solid-injection type. These have been operating for five years on a mixture of 20 deg. Baumé gravity. This is made by mixing oil of 14 to 16 deg. with another oil of 30 to 31 deg. Baumé.

Our engines are equipped with a water-jacketed exhaust pipe and elbow, which furnishes hot water to heat the fuel oil to a temperature of about 140 deg. F. at the engine fuel pumps. We have three shutdowns every 24 hours, and change over to the lighter 30 to 31 deg. oil about fifteen minutes before each shutdown, so as to have the lighter oil at the pumps to start upon. This causes a slightly larger amount of the lighter oil to be used during the month than is indicated by the figures for the 2-to-1 mixture, but does not exceed a proportion of 64 to 36 per cent. We have proved to our own satisfaction that the important thing is to heat the fuel oil fed to the engine to as high a temperature as can be reached by means of water circulated in the jacketed exhaust pipe.

Considering that an air-injection engine is considerably more complicated than one of the solid-injection type, it seems to me that the latter type is the better for the plant under consideration. THOMAS C. HULTON,
Abras Grandes, Cuba. Compania Minera Chambas

What Has Happened to That Boiler Room Bonus?

WITH REFERENCE to the article by R. K. Long in the Jan. 28 number of *Power* on "What Has Happened to That Boiler Room Bonus?" it is evident that Mr. Long believes that the human element is just as important as ever.

Granting this is true, there is a different human element in the boiler room now than there was a few years ago. Modern methods and equipment have transformed the boiler room from a dark, smoky sweat shop to a clean pleasant place in which to work. In the days gone by a fireman was classed according to his bulk and how well he could handle a shovel and slice bar. That type of fireman has had his day, and with him went the boiler room bonus. The man in the boiler room today gets about three times the money per day or week for the same amount of work he did a few years ago. Furthermore, modern equipment is guiding the fireman now, and he has time to look ahead for a bigger job. College men are spending much of their time in the boiler room and are getting results for their efforts.

I do not agree with Mr. Long that the bonus has failed because of the management. A man who wants to gain knowledge in the boiler room does not need a bonus.

The efficiency of the average power plant is higher now than ever before, and it is due not only to a better grade of equipment, but also to a better class of firemen.

Des Moines, Iowa. HENRY STUART.

From Among Readers' Problems

Conducted by
L. H. MORRISON

MEASURING BLOWDOWN BY CHLORIDE TEST.—*Can the per cent of blowdown be figured approximately correct by the sodium chloride method, using the silver-nitrate test? For instance, a boiler is being fed 40,000 lb. of water per hour containing 6.5 grains per gallon of sodium chloride, and the boiler water shows 120 grains per gallon of sodium chloride.*

If this latter figure is divided into 6.5 would the quotient be the per cent blowdown, in this case 5.4 per cent? If so, what would be the result if only about 65 per cent of the boiler-feed water contained 65 grains per gallon sodium chloride, the balance being condensate?

If 5.4 per cent represents the blowdown can it be assumed that 94.6 per cent of the water fed to boiler is evaporated into steam regardless of a slight amount of carryover? H.S.B.

You are correct in your assumption that the chlorides in the blowdown can be used to find the amount of the blowdown. For example, if we feed a given total number of grains in the feed water, $6.5 \times 40{,}000$ in your case, for the boiler contents to maintain a constant concentration this amount must be removed. If the blowdown has 120 grains per pound, obviously the blowndown bears the relation to the feed of $\frac{6.5}{120} = .054 = 5.4$ per cent.

If only 65 per cent of the feed carries the chloride, then the average grains is $\frac{65}{100} \times 6.5 = 4.22$ grains per pound of feed water. If the blowdown shows 120 grains, as before, then the per cent blowdown is $4.22 \div 120 = 3.5$ per cent.

If 5.4 per cent represents the blowdown, the remainder, 94.6 per cent, must leave by the steam lines. The amount of moisture in the steam will determine how much of the boiler feed is actually converted into steam.

RATIO OF COMPRESSION.—*What is the ratio of compression, in a vacuum pump taking in air at 1-lb. abs. pressure and discharging it at 14-lb. abs. pressure? What is the ratio in a compressor that raises air from atmospheric to 90 lb. gage?* J.D.H.

The compression ratio of any compressor is that of the intake to the discharge absolute pressure. In case of the vacuum pump the ratio is $14 \div 1 = 14$. For the compressor the ratio is $(90 + 14.7) \div 14.7 = 7.1$, since the absolute pressure is taken as gage plus 14.7.

EXPANSION OF PIPE—*A 6-in. pipe 700 ft. long carries 30 lb. steam pressure. How many inches will it expand?* J.W.P.

A piece of steel, such as pipe, will expand .00000548 its length for each degree of temperature change. The pipe line is under 30 lb. gage pressure, so that its temperature is the saturated temperature corresponding to 30 lb. gage, or 274 deg. F. Assuming that the pipe when cold is at 60 deg., there is a rise of $274 - 60 = 214$ deg. F. Each foot then expands $0.00000548 \times 214 = 0.001173$ ft. The 700 ft. will expand 0.82 ft., or 9.84 inches.

However, pipe insulation is never perfect and the temperature of the steel is less than that of the steam. In an uninsulated pipe buried in the ground, the average wall temperature may not exceed 150 deg. F.

EFFECT OF COMPRESSION RATIO ON THE TEMPERATURE.—*Has the ratio of compression in a single-cylinder compressor any effect on the discharge temperature?* J.D.H.

Yes, the cooling effect of the cylinder jacket of a single-stage compressor is not enough to hold the temperature constant. The actual temperature depends upon compressor speed and jacket-cooling effect.

If the jacket removed no heat the temperature would have the relation

$$\frac{T_d}{T_i} = \left(\frac{P_d}{P_i}\right)^{0.29}$$

If the discharge is 90 lb. abs. and the suction atmospheric

$$\frac{T_d}{T_i} = \left(\frac{104.7}{14.7}\right)^{0.29} = 1.76$$

If T_i, the atmospheric temperature, is 60 deg. F., or 520 deg. abs., then $T_d = 1.76 \times 520 = 915$ deg. abs., or 455 deg. F. The jacket cooling will reduce this to around 300 deg. F.

PREVIOUS QUESTION

Discussed by Readers

THE QUESTION

IN A water-works plant when the delivery head is 160 ft., the suction lift 12 ft. and the required capacity 500 gal. per minute, would a centrifugal pump or would a triplex pump work with more efficiency? Electricity costs 3 cents per kilowatt-hour. J.B.H.

THE TOTAL head is 172 ft., corresponding to 74.3 lb. per square inch pressure. A double-acting triplex pump featured in a leading manufacturer's catalog is rated at 530 g.p.m., 75 lb. working pressure, and its efficiency is given in curves of the same catalog as 85 per cent, although the figures given bring out only 84 per cent. This pump would fit nicely into the requirements stated in the question.

One of the upward of 150 pump installations, mostly centrifugal and deep-well, which my company serves has operating characteristics almost equal to those stated in the question. The pump is a centrifugal single-stage, double-suction, capacity 425 g.p.m., head 172 ft., r.p.m. 1,750. The electric motor is a 30-hp., 1,755-r.p.m., 220-volt, 3-phase, 60-cycle machine. The pump works 12 hr. each day. Over-all efficiency is 59.60 per cent. Assuming a motor efficiency of 90 per cent, pump efficiency is 62.22 per cent.

So many other features may enter into the problem of selecting the right pump for the installation mentioned in the question that pump efficiency alone would not decide the question. Perhaps over-all efficiency would better determine a choice, together with other considerations. Over-all efficiency of the triplex pump mentioned will be reduced considerably if only 60-cycle current is available; since in this case the pump would have to be driven through a power transmission. If 25-cycle current is available, a 205 to 215 r.p.m. motor could drive this pump directly, but that is an expensive motor.

Centrifugal pumps are guaranteed to lift their full rated capacity to a total net suction head of 15 ft. maximum at sea level, provided the suction pipe is built air tight, and this total head is

the total of the actual lift plus friction in pipe, foot valve and strainer, plus velocity head. Power pumps, on the other hand, will easily handle lifts up to 22 feet.

The difference in over-all efficiency in favor of a triplex pump may be some 8 per cent. Assuming a 30-hp. motor, 12-hr. operation, and current at 3 cents per kilowatt-hour, the annual saving would be $233.28, which would justify a triplex pump installation costing $3,894 more than a centrifugal, provided maintenance charges were to be equal in both installations, which they would not be. J. F. GONZALEZ.

Guayama, P. R.

THE HORSEPOWER required to pump water is given by the following formula:

$$hp. = \frac{W \times H}{33{,}000 \times E}$$ in which

$hp.$ = horsepower,
H = total head, including suction and discharge head and friction heads,
E = over-all efficiency of the system.

The mechanical efficiency of a triplex pump will, for this size, average about 70 per cent. The mechanical efficiency of a three-stage centrifugal pump will be about 55 per cent to 60 per cent.

From the standpoint of mechanical efficiency, a triplex pump when well maintained shows an advantage over the centrifugal pump.

From the standpoint of maintenance, simplicity, first cost and continuous efficiency, the centrifugal will show up to a better advantage than the triplex in spite of the slightly higher initial efficiency of the latter type of pump.

Clemmons, N. C. R. H. PICKENS.

THE water-horsepower needed would be 21.7. The efficiency of a centrifugal pump of 500-g.p.m. capacity, pumping against a 172-ft. head, is from 50 to 55 per cent, say 52.5 per cent. It will require $\frac{21.7 \times .746}{52.5} = 30.9$ kw. costing $30.9 \times .03 \times 24 = \$22.25$ per day with electricity at 3 cents.

The efficiency of a triplex pump for these conditions would be 77.5 per cent, or a difference of 25 per cent, causing a decrease in cost of power of $\frac{25}{72.5} = 32.2$ per cent, or $7.20 per 24 hours.

This is theoretical, and is counterbalanced to a certain extent by the cost of packing, oil, rod, liner, belt, and gear renewals, as well as service, outages and supervision. R. F. BENNETT,

Crystal Tissue Company.

Middletown, Ohio.

TOTAL EFFICIENCY of a two-stage 500-g.p.m. centrifugal pump using a Francis type of impeller and an induction-motor drive will be 78 per cent, hence power used for this combination is $21.7 \times 100 \div 78 = 27.8$ electrical horsepower, and the cost of operation with energy at 3 cents per kilowatt-hour is $27.8 \times .746 \times .03 = \$0.622$ per hour.

With the same theoretical water horsepower of 21.7, a triplex pump driven through reduction gears by an induction motor will have a net pumping efficiency of 75 per cent, hence the electrical power load will be $21.7 \times 100 \div 75 = 29$ electrical horsepower, and power consumption will be $29 \times .746 \times .03 = \$0.648$ per hour.

As the net cost of pumping, however, must necessarily include the interest on the original investment, depreciation, repairs, and maintenance, a centrifugal pump will show a lower over-all pumping cost than that of any reciprocating type of pump, and is therefore the more economical choice.

Bayonne, N. J. E. A. BAERER.

ASSUME the following efficiencies: Centrifugal pump 80 per cent, squirrel-cage induction motor 87 per cent, triplex pump 85 per cent, and its slip-ring motor 88 per cent. The cost of pumping 1,000 gal. with the centrifugal pump would be 2.31 cents, and with the triplex pump 2.16 cents. This shows an apparent saving of approximately $400 per year for the triplex. This saving is not practical, however, as the triplex would not hold this efficiency without considerable maintenance, which would offset this apparent gain in operating cost. Efficiency of the centrifugal pump will remain constant over a long period of operation.

All other items that make up the total operating cost, such as first cost, space required, and depreciation, are much in favor of the centrifugal pump. If alternating current is used, a slip-ring motor will be necessary for the triplex, owing to the starting torque required; whereas a squirrel-cage motor could be used with the centrifugal pump. A centrifugal pump would be the best investment. F. SHIRES,

Ford Motor Company.

Detroit, Mich.

A Question for Our Readers

WE are installing a gas-fired hot-water heater, taking the water direct through the meter from the city mains, and the city pressure is used to force the water through the house lines. The inspector insists on a safety valve, but I cannot see how over-pressure is possible. Is a safety valve necessary? P.V.R.

Suitable answers from readers will be paid for and published in the April 8 number.

SINCE the cost of power is given in electrical units, I will assume that the pump is to be motor driven. The centrifugal pump I will assume is direct connected to an 1,800-r.p.m. induction motor.

A pump that will satisfy the conditions of the problem will have an efficiency of 63 per cent. A horsepower formula found in most pump catalogs gives $\frac{G.P.M. \times H}{3{,}960 \times E}$ = hp., when H is the total head and E the pump efficiency. Translated into figures, this becomes

$$\text{horsepower} = \frac{500 \times 172}{3{,}960 \times .63} = 34.4.$$

A 35-hp. induction motor has a 90 per cent efficiency. Therefore the over-all horsepower required for the pumping unit is $\frac{34.4}{.90} = 38.2$. Since this is only 9 per cent overload for the 35-hp. induction motor it will be safe to use it. Cost of running the unit for one hour will be $38.2 \times .746 \times .03 = \$0.85$.

A triplex pump to satisfy the conditions of the problem will be 61 per cent efficient at 51 r.p.m. This means that there must be some sort of speed-reduction mechanism between the pump and the motor, for which there is a wide range of choices, from belts, chains, worm gears, spur gears and combinations of high-speed motors with large gear ratios and low-speed motors with small gear ratios.

Since low-speed motors affect the whole electrical system by increasing losses through the lower power factor of the motors, they are more expensive to operate than are high-speed motors. I will assume, as with the centrifugal pump, that the triplex is to be driven by an 1,800-r.p.m. induction motor, connected to the pump through two spur-and-pinion sets, each having a ratio of 1 to 6. Each gear set will have an efficiency of 97 per cent.

The horsepower required to drive the unit will be:

$$\frac{500 \times 172}{3{,}960 \times 61 \times .9 \times .97 \times .97}$$

$= 42.2$) and a 40-hp. motor will have to be used. There is virtually no difference between the efficiency of a 35- and a 40-hp. induction motor, so the cost of running this unit for one hour will be $42.2 \times .746 \times .03 = \$0.945$.

On a basis of 8,000 hr. operation in a year, the money saved by installing the centrifugal instead of the triplex pumping unit will be $8{,}000\ (.945 - .85) = \$760$. R. A. DICKSON.

Newark, N. J.

[A surprising thing about all the answers received is the wide variations in assumed pump efficiencies. Undoubtedly low-efficiency centrifugal and triplex pumps are sold, but there is no reason why high-efficiency pumps should not be used for the job under discussion, in which event the efficiencies of the two types are practically identical.—L. H. M.]

WHAT'S NEW IN PLANT EQUIPMENT

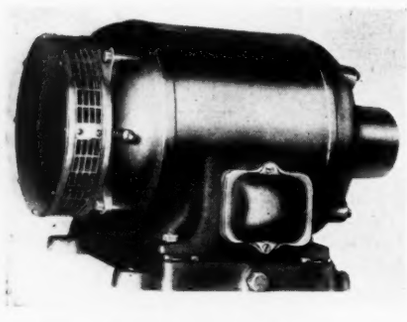
HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING, TRANSMITTING AND APPLYING THE POWER SERVICES

Totally Inclosed Fan-Cooled Motor

COMPLETE isolation of the stator, rotor and other internal parts from the outside air is the important feature of a new line of totally inclosed fan-cooled motors introduced by the Century Electric Company, St. Louis, Mo. In most of the ratings the new line has, in addition, the size advantages of a standard open-rated motor.

As will be apparent from the illustration, the fan and its housings are externally mounted on the front end of the motor opposite the pulley end. Cooling air is drawn in at the pulley end, circulated around and over the rear coil guard, through air passages between the field core and the frame, out over the coil guard on the front end and finally through the fan. Blades are radial, so the fan is equally effective regardless of the direction of rotation. Air within the motor shell is also made to circulate and serve as the heat-transferring medium from the motor proper to the radiating surfaces of the protecting shell, where it is carried away and dissipated by the cooling air.

As all the internal parts of the motor are tightly sealed against dust, compressed air can be used to blow out the cooling-air passages.

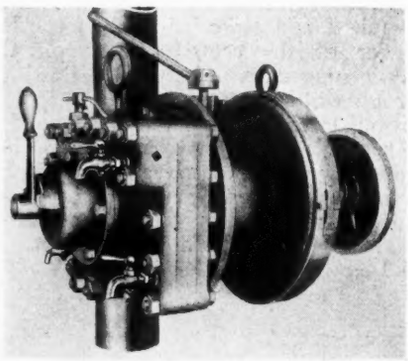


Totally inclosed motor with externally mounted fan and housing

Single-Drum Air-Steam Hoist

TWO improved models, Nos. 8 and 10, of the Leadville single-drum air or steam hoist are being put out by the Gardner-Denver Company, Denver, Col. They have a greater capacity than the present models.

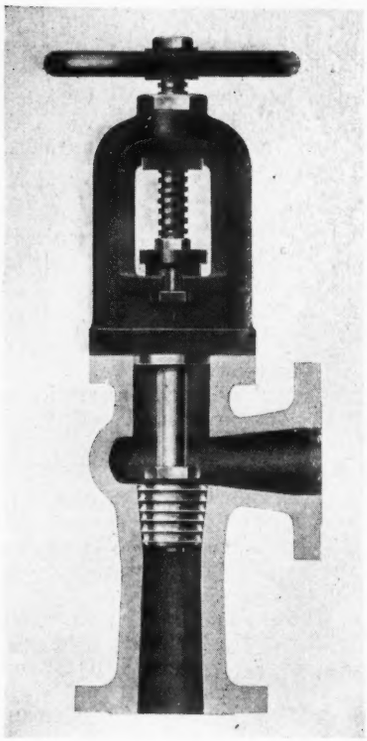
Improved engine design with balanced pistons and air control through balanced spool valves with increased port area have increased the efficiency of the new models, according to the manufacturer. Model 8, illustrated, is rated at 6 hp., with a rope pull of 2,000 lb. at a speed of 150 ft. per minute. The drum is 6 in. in diameter by 9¼ in. wide, with a capacity of 620 ft. of ⅜-in. rope. All moving parts are fully inclosed. Brakes are of the post type, operated with a long lever. A non-destructive clutch connecting and disengaging the drum from the gear set is operated with a lever. Crankshafts of heavy forged ground steel run in ball bearings.



Hoist operated by steam or air

Multi-Stage Valve for Stop and Pressure-Reducing Services

THE INCREASING use of high steam pressures has made necessary important developments in valve design to meet the demands imposed by higher pressures. In any type of valve the seat and disk are essentially the only parts subject to wear or erosion in service, which vary in direct relation to the pressure and discharge velocity through the valve.



Sectional view of multi-stage blowdown valve

With a view to providing a valve having a minimum number of parts and one that is adaptable to practically any service and any pressure now in commercial use, the multi-stage valve, designated "multi-val," illustrated, has been developed by the Multi-Valve Company, New London, Conn.

The principle of multi-stage expansion is employed to give a relatively low-flow velocity through the valve and thus reduce the effects of wire drawing to a minimum. A Venturi-shaped section of the valve body serves as the seat, and a plug of stainless steel fitted with six or more seating lands having annular expansion chambers between them comprise what is usually termed the disk. The expansion chambers cause the total pressure drop to be distributed through several stages, resulting in

low velocity, and minimize the effects of wire drawing in the nearly closed or throttling position of the valve.

The valve shown in the accompanying illustration is designed especially for boiler blowdown service with the pressure on the large end of the plug. For feed-line or pressure-reducing service, the pressure is on the small end of the plug, so that any expansion is utilized to reduce velocity flow through the valve.

Among advantages claimed for this valve are that any scale or dirt carried over is first ground and then serves as a lapping material for the lands of the plug, which burnishes tight-seating contacts in the converging inside wall of the valve outlet with each opening and closing; ring seating contacts improve with use; slow opening of the valve, by virtue of its design, increases safety, and it is labyrinth sealed when closed.

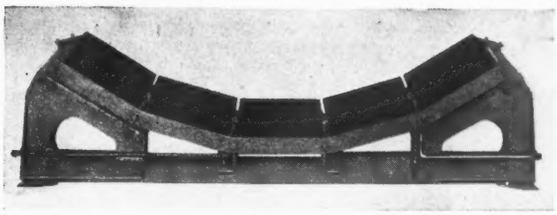
Blow-off valves as illustrated are available in sizes from $1\frac{1}{2}$ to $2\frac{1}{2}$ in. for pressures up to 600 lb. It is also available in angle and straightway patterns, in sizes from $\frac{3}{4}$ to $2\frac{1}{2}$ in. For pressures up to 200 lb. the body is of cast iron, and for pressures above 200 lb. of cast steel. In all sizes the plug and stem are of stainless steel.

Overload Switch for Small Motors

A FREE-TRIPPING thermal overload switch for small motors put out by Cutler-Hammer, Inc., Milwaukee, Wis., is illustrated. The

Small across-line starter

new switch has push button start and stop and a time-limit type of thermal overload. The switch is reset by pressing the start button, which also restarts the motor.



Rubber-cushioned idler with cleaning strips

Improved Rubber-Cushioned Idler for Belt Conveyors

A RECENT improvement in the Robins rubber-cushioned idler for belt conveyors designed especially to absorb the shocks of falling chunks of coal, rock, etc., at the point of loading, is the use of steel strips fastened to both sides of the idler, as shown.

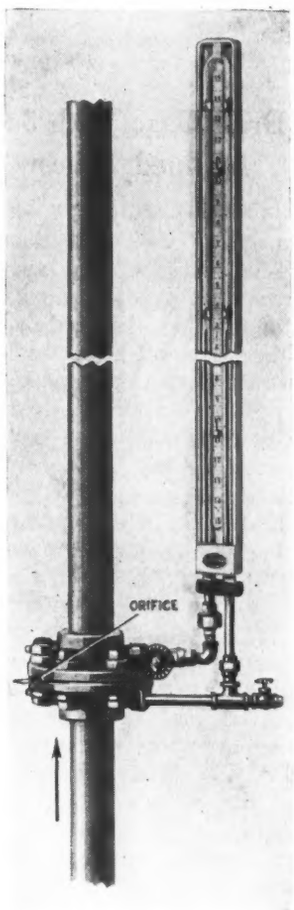
In addition to preventing spilled material from banking up against the pulleys, the strips serve as a cleaner to take off any sticky material that may adhere to the pulleys. The design of the end brackets also has been changed to give a hooded shape to protect the end bearings from damage. The pulley shown is a product of the Robins Conveying Belt Company, 15 Park Row, New York City.

Expansion Bends for Rigid Conductors

A STANDARDIZED line of expansion bends for connecting rigid conductors to transformer and oil circuit-breaker studs is announced by the General Electric Company, Schenectady, N. Y. The bends, which are made from rectangular copper bar, prevent the bushings from being subjected to strains resulting from thermal expansion of conductors and uneven settling of the transformer and oil circuit breaker foundations with relation to the structure. They are applicable to copper bar and copper tubing. In the latter case it is necessary to flatten the tubing at the point where the expansion bend is attached or to attach a terminal to the tubing and thence to the expansion bend.

Inverted-Type Manometer for Measuring Liquids

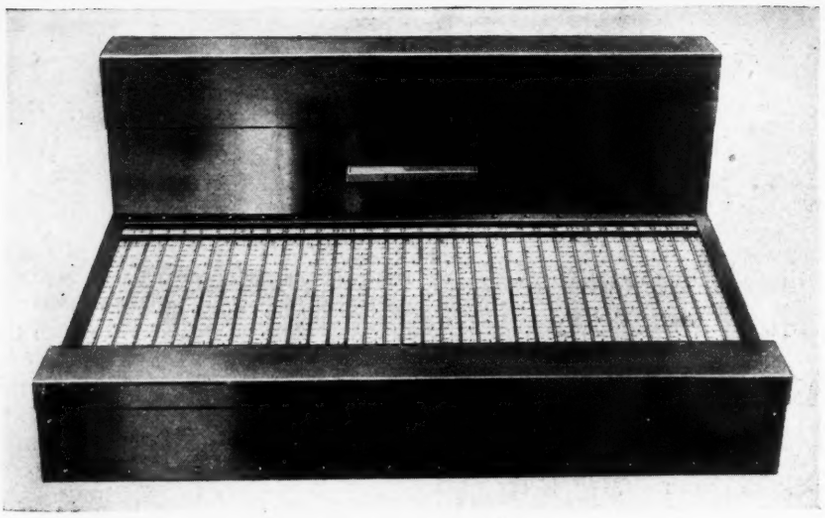
THE inverted-type manometer shown in the illustration is similar in most respects to the standard types made by the Meriam Company, Cleveland, Ohio, except that the bend of the U-tube is at the top instead of at the bottom. It is connected in the usual manner—one arm of the U-tube being piped to each of the points between which the pressure is to be measured; or, in the case where rate of flow is to be found, to either side of an orifice disk of known



Inverted manometer connected to either side of an orifice

size place directly in the pipe line.

The chief difference between the inverted and the ordinary type is that the liquid levels in the two arms are actual levels of the liquid measured instead of being mercury or other special liquid placed in the tube itself. A big advantage of this method is that should the differential pressure be too great there is no mercury to be "blown over" and lost. The liquid from one side will merely flow over to the other through the manometer until the pressure drops, when it is immediately ready for use again.



Ellison 34-inclined-tube draft gage

Draft Gage With 34 Inclined Tubes

AN OUTSTANDING development for draft measurement is the 34-inclined-tube gage shown in the accompanying illustration. Two gages of this type designed by Lewis M. Ellison have been built by the Ellison Draft Gage Company, Chicago, Ill., to serve underfeed stokers installed at the Beacon Street plant of the Detroit Edison Company.

Each stoker is equipped with 34 Venturi nozzles, in a common windbox, that point upward toward the grate. In each nozzle is a damper for controlling the air flow at a uniform rate, as indicated by a straight-line differential reading on the gage, one tube for each nozzle. The zero end of the gage is connected with the windbox under a common pressure. At the other end of the gage each of the tubes is piped to one of the nozzles on the grate side of the damper, and is sealed up to 6-in. pressure.

The scale is 10 in. long and is provided with 1-in. sliding movement for zero adjustment. Tubes are spaced on 1-in. centers, with the scale graduated to read 1 in. differential pressure in 0.01 in. on one side of the tube, in black graduations, and on the other side of the tube to read the air flow, or square root of the differential pressure, in red graduations.

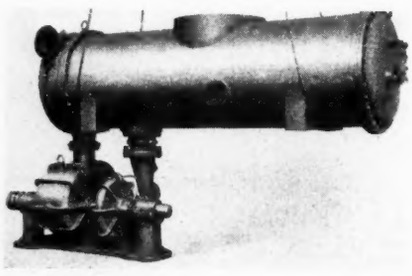
In the construction of the gage frame care was exercised to minimize weaving and to provide means for placing the gage in the same position, with reference to tube inclination, in which it was standardized. The gage frame was constructed of $\frac{1}{4}$-in. brass plate, 36 in. wide, and was provided with four adjustable supports with floating bearings, one at each corner, for leveling the gage on a metal stand. Each of the four sides was provided with a datum, or leveling surface, on which the gage is leveled by a sensitive portable bench level.

In calibration of the 68 tubes at $\frac{1}{4}$-in. intervals, nearly all points checked exactly, none exceeding an error of 0.005-in. minus or plus.

Unit-Type Surface Condenser

WITH a view to simplifying the installation of a surface condenser and its auxiliary equipment in small power and industrial plants, the unit-type condenser illustrated is now being put out by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

In this unit the circulating and condensate pump are attached directly to, and are located underneath, the shell of the condenser. The two pumps are mounted on one base, with their impellers on a common shaft and arranged for driving with a single motor. Provision is made for taking care of any difference in expansion due to temperature changes in the shell by means of an expansion joint in the condensate pump connection. The complete unit is placed beneath the prime mover it serves, thereby reducing to a minimum the amount of space required.

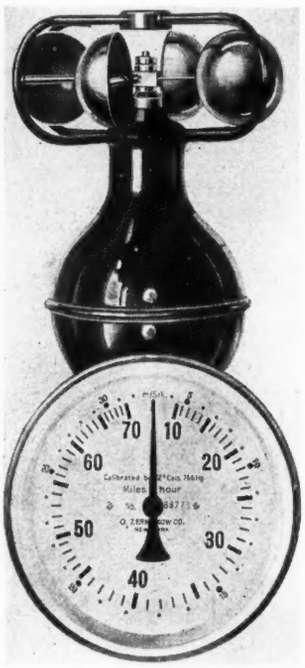


Condenser with combined circulating and condensate pump

Anemo Tachometer

DESIGNED to provide a convenient means of ascertaining the capacities of fans, compressors, blowers and similar equipment, the anemo tachometer, or air velocity meter, illustrated, combines a Robinson cup-cross and a centrifugal type tachometer.

Where exposed to an air current the cup cross receives a definite average angle velocity in such a manner that the average absolute speed of the cup center is in approximately constant relation to the wind velocity.



Air-velocity meter

The rotation of the cup is transmitted through a ball-bearing spindle to the hand of the instrument, which has double graduation from 10 to 70 miles per hour and 5 to 35 meters per second.

It is claimed by the manufacturer that for the net result of measurements it is immaterial whether the suction or pressure conduit is tested or whether the air current is laminary or turbulent.

The size of the dial is 4 in. and the net weight of the instrument is 2 lb. When inclosed in carrying case, which measures $4\frac{3}{4}$ in. wide, $4\frac{1}{2}$ in. high and 10 in. long, the gross weight is 4 pounds.

NEWS of the FIELD

Spot News

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PARTIAL APPROVAL *of the Couzens bill was expressed last Wednesday before the Senate Committee on Interstate Commerce by Secretary of the Interior Ray Lyman Wilbur. He favored the appointment of a full-time independent power commission, but insisted it should draw on the Departments of War, Interior and Agriculture for most of its engineering and accounting services.*

•

CONSTRUCTION *of the largest single pumping station in the world will be started soon by the City of Detroit, Mich., to meet its increasing demand for water. The station will contain an installation of 28 centrifugal pumps and a 30,000-kw. steam-electric power plant.*

•

ANNOUNCEMENT *has just been made by officials of the Virginia Public Service Company that the company will soon start erection of a new steam generating station at Bremo Bluff, Va. With an initial installation of 20,000 hp. the plant will have an ultimate capacity of 100,000 horsepower.*

•

SAN FRANCISCO *county and city will vote at the next primary election on the issuance of bonds to finance the purchase of the local distribution systems of the Pacific Gas & Electric Company and the Great Western Power Company, which will be used to distribute power generated at the Moccasin plant of the Hetch Hetchy municipal hydro project.*

•

CONTRACT *has been awarded to the Stone & Webster Engineering Corporation for the design and erection of an extension to the Benning station of the Potomac Electric Power Company. This construction, costing about $3,000,000, will include an addition to the station building and the installation of a 30,000-kw. turbine-generator unit.*

New York Committee Submits Report on Public Service Commission

Majority and minority of investigating body differ mainly on method of fixing utility rate base

SEVENTEEN specific recommendations are contained in the report of the committee on revision of the New York Public Service Commission Law, submitted to the Legislature, March 3. The chief point of difference between the majority and minority of the committee is in the establishment of a rate base. Both recommend initial valuations of all existing utility properties, except those of steam and street railways, by means of a state-wide survey. It is estimated that the task would occupy three or more years and would require the expenditure of several million dollars.

When the valuations are established, however, the majority proposes that the Public Service Commission be authorized to enter into contractual agreements with the utility companies whereby these valuations shall be used as the rate base for existing properties up to ten years. Future investments during the period of the contract shall be added to the initial valuation, according to the amount actually expended and approved by the commission, and the rate regulation during such period shall be exercised by accounting control. At the end of the period the valuation shall be revised and new agreements entered into.

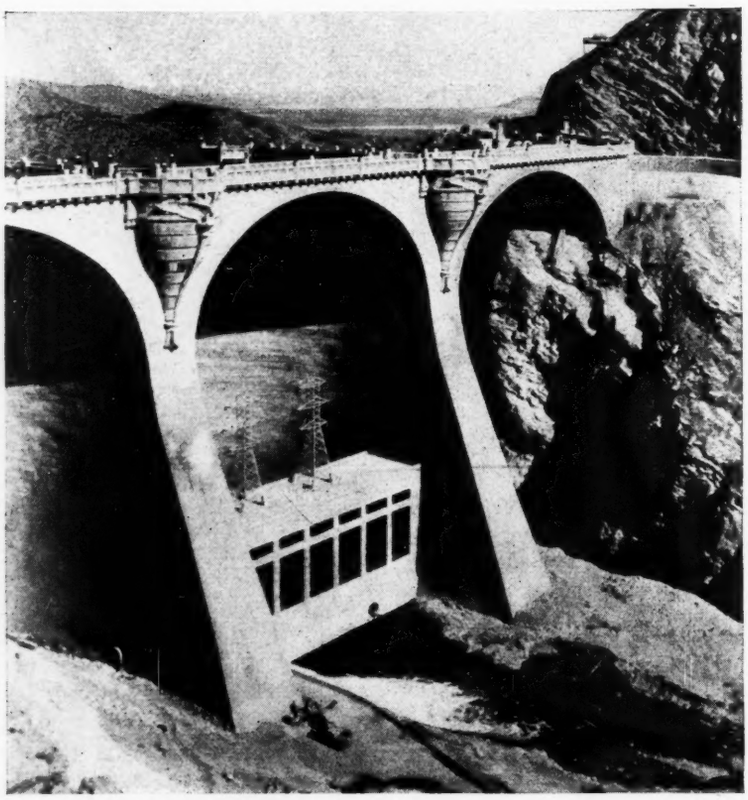
THE MINORITY recommends that the initial valuations, when once determined, shall remain unchanged in the future without regard to price fluctuations, costs of construction or other conditions. The amounts of actual and reasonable cost of new properties shall be entered into the accounts of the companies and added to the initial valuations, thus enabling the commission to have always available, through accounting control, the total rate base. Provision is made for ordinary maintenance, depreciation and retirement of any unit of property.

In addition, the report points out four points of difference between the majority and minority. In the matter of valuation, the plan of the minority would be mandatory and perpetual, while that of the majority would be voluntary agreement between the utility and the state commission under authority of the legislature and for a limited period. In relation to the People's Counsel to represent the public interests, the minority urges appointment by the Governor, the majority by the Attorney-General. In utility salary policy, the minority proposes a minimum raising of salaries for certain positions, while the majority calls for a comprehensive survey of present salaries looking toward classification and standardization. The minority recommends transfer of functions of the Public Service Commission relating to grade crossing elimination to the Department of Public Works. To this the majority objected because the asserted advantage was not sustained by facts.

TWO OTHER major recommendations contained in the report are: that the authority of the commission be extended so as to enable it to secure complete information regarding the identity of stockholders of utility corporations and transactions between utility corporations, holding companies, affiliated service agencies and other affiliated interests; and that the authority of the commission with respect to accounting control, security authorizations, reorganizations, mergers, transfers of franchises or property and acquisition of stock of utility corporations be strengthened and extended.

Other recommendations include establishment of procedure for recovery of reparations in cases where rates have been declared unjust or unreasonable; regulation of sub-metering companies; the study of interstate problems affecting regulations; extension of jurisdiction over private water companies, motor bus companies and telephone companies with property values of less than $10,000; the establishment of a division of rural electrification; the establishment of a bureau of research and valuation; that utility corporations be required to give notice of proposed changes of rates by public advertisement and by notice to consumers with their bills; that the legislature urge upon Congress the revision of the Federal Judicial Code so as to make it possible for state courts to make primary determinations in rate cases prior to appeal to the federal courts.

Coolidge Dam Dedicated



CALVIN COOLIDGE, former president of the United States, dedicated on March 4 the dam that bears his name. Located on the Gila River near Globe, Ariz., it was recently completed at a cost of $6,500,000. It is the first dam of multiple-dome construction and rises 220 ft. above bedrock. With a storage capacity of 1,200,000 acre-feet, it will supply water for the irrigation of 122,628 acres of land. The hydro-electric power plant built under the middle dome has a capacity of 10,000 kw., and will supply electricity to farms.

▼ ▼ ▼

Two New Hydro Projects Before Commission

The Pacific Gas & Electric Company of San Francisco has applied to the Federal Power Commission for a preliminary permit covering a project on Bear River, Cold Creek and the North Fork of the Mokelumne River in Amador County, Calif. The proposed development includes a concrete arch dam 220 ft. high in Bear River, forming a reservoir with a capacity of 50,000 acre-feet; a conduit extending from the dam to a proposed power house near the applicant's Salt Spring dam; and a conduit 4,000 ft. long diverting water from Cold Creek to the foregoing conduit. It is planned to install 34,000 horse power.

Wallace Huntington, of Portland, has applied for a preliminary permit covering a project on the McKenzie River in Linn County, Ore. It is proposed to construct a dam at the outlet of Clear Lake. From that point it is to be conducted 3,500 ft. by a conduit to power house No. 1. A second dam will be constructed below from which a conduit half a mile in length will extend to power house No. 2. In like manner two other dams and power houses will be erected at points further down the stream. It is planned to install 44,500 hp. to be used for public utility purposes.

U. of Illinois Announces Research Assistantships

Application for appointments to the fourteen research graduate assistantships maintained by the engineering experiment station of the University of Illinois at Urbana are due on April 1, according to a recent announcement of the director of the station. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

An appointment to the position of research graduate assistant is made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of master of science will be conferred. Half of the time of a research graduate assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study. Research work and graduate study may be undertaken in all important branches of engineering and science.

Montevideo to Erect 50,000-kw. Plant

One of the largest individual power plant orders ever placed in Great Britain has just been received by the Metropolitan Vickers Electrical Company, Manchester, England. The contract involves the supply of complete machinery and plant for a new power station at Montevideo, Uruguay, and includes two 25,000-kw. turbine-generator sets, each with direct-coupled exciter, and a 750-kw. auxiliary alternator; a central-flow condensing plant with motor-driven circulating and extracting pumps, and full-capacity air ejectors; the necessary water-tube boiler equipment; switchgear and control apparatus; 7,400-kw. three-phase station auxiliary transformers; accumulators and charging equipment; cable work and automatic telephones.

The contract, which does not include civil engineering work or buildings, amounts to nearly $3,750,000. The site of the new station is close to the sea wall and less than half a mile from the existing power station.

Fatigue Causes Scrapping of Naval Destroyers

Fatigue in the metal of Yarrow type boilers on 58 naval destroyers necessitates the scrapping of these craft and their replacement by other destroyers now out of commission. This was explained to the House Appropriations Committee recently by Admiral Charles F. Hughes, of the Bureau of Engineering, who sought to obtain permission to spend $1,350,000 for the purpose of overhauling sufficient destroyers now laid up at the various navy yards to replace the craft that will be scrapped.

Admiral Hughes said that when cracks were discovered in one of the boilers the other craft were examined. It was found that the cracks existed in practically every boiler. The cracks ran from tube hole to tube hole, he said. After these cracks were etched out by milling and the application of acid, it was disclosed that they extended into the metal. In describing the situation, Admiral Hughes explained, "there was

an inherent weakness in the design of the boilers where the metal was thicker at one part than at the other—it tapered—the tubes came in at an angle. There was a counter-bore that went into the tube."

After consulting naval experts and outside engineers, Admiral Hughes said that the opinion was reached that there must have been a slight motion in the metal that caused fatigue. Both naval and outside engineers agreed that the boilers were unsafe for further use, he stated. In answer to questions by committee members he said that it would not be economical to equip the condemned destroyers with new boilers.

American Co. Considering New Zealand Project

On behalf of the American Cyanamid Company, H. P. Gibbs has inspected the concession granted by the New Zealand Government to New Zealand Sounds Hydro-Electric Concessions, Ltd. The area investigated is located in the Southland fjiords between Lake Manapouri and Deep Cove, Smith Sound. The concessions obtained its license in 1926 to harness the waters discharging into Smith Sound, estimated to furnish 50,000 hp.; and to convey the waters of Lake Manapouri to Deep Cove by a tunnel approximately 6¼ miles in length, giving power sufficient to generate 250,000 hp. Water rental of 24c. per kilowatt is payable to the government five years after the power is first used. The Crown has the right, after the expiry of 30 years, to purchase the undertaking at a price to be fixed by arbitration.

High Efficiency Expected From Long Beach Unit

After meeting all expectations in governor and over-speed trip tests conducted during the past month, unit No. 11 of the Southern California Edison Company's Long Beach steam station has been placed in service on the company lines. Unit No. 11 is a duplicate in all its major features of unit No. 10 of the same plan, the only noteworthy change in design being in the steam superheaters, which for the new unit are of single-pass design instead of three-pass as in unit No. 10. The new boilers were thoroughly broken in in advance of operation by bypassing the steam to unit No. 10.

The over-all plant efficiency for unit No. 10 for the year 1929 was 12,848 B.t.u. per net kilowatt-hour and the improved superheater design for unit No. 11 is expected to result in a still higher over-all plant efficiency for this unit. The addition of the new unit increased the capacity of the Long Beach steam station to 415,000 kw., and the steam generating capacity of the Edison company to 461,000 kilowatts.

Pendred Made President of British I.M.E.

Loughnan St. L. Pendred, prominent British mechanical engineer and editor of *The Engineer,* was inaugurated president of the Institution of Mechanical Engineers on Feb. 21.

Educated at Finsbury Technical School, Mr. Pendred served his apprenticeship with Davey, Paxman &

Loughnan St. L. Pendred

Company, Ltd., of Colchester, England. After this training, he engaged successively in development engineering at the works of Ven den Kerchove of Ghent, Belgium; Chemin de Fer de l'Ouest of Paris and Rouen, France, and Whitworth & Company of Elswick, England. In 1896 he joined the staff of *The Engineer,* working as an assistant editor until 1905 when he was made editor.

Last October, Mr. Pendred headed the delegation of British engineers to the World Engineering Congress in Tokio, Japan. In April he will represent his colleagues at the 50th anniversary celebration of the American Society of Mechanical Engineers, where he will present a paper on engineering progress in his country.

A.S.H.V.E. to Move

By March 20, the American Society of Heating & Ventilating Engineers will be housed in its new headquarters on the 31st floor of the New York Life Insurance Building, 51 Madison Ave., New York City, where more commodious quarters have been selected by the council to care for the increasing society activities. Present offices in the Engineering Societies Building are given up after a tenancy of 19 years. During this time the organization has made great strides, growing from a membership of about 400 to more than 2,000, so that for many of the older members there will be pleasant recollections of association with the founder societies and their encouragement.

News of Canada

West Kootenay to develop Pend Oreille—Power demand increasing in northern Ontario — Power Corporation unable to find site

ACCORDING to a decision just handed down by the British Columbia Water Power Board, the West Kootenay Power & Light Company will have an opportunity to develop the entire flow of the Pend Oreille River, but only on condition that it immediately and permanently supplies the Reeves McDonald Mining Company with power for all its mineral development at fixed rates. These rates will be the same as the Consolidated Mining & Smelting Company pays the independent East Kootenay Power Company for power to operate the Sullivan mine at Kimberley. This brings to an end the important battle which has been waged for some months over control of the Pend Oreille water powers. The West Kootenay company has formally agreed to these terms and must proceed with its development on that basis.

WITH THE RAPID development of mining and other industries in northern Ontario, the demand for electric power in that section of Canada is steadily increasing. The Canada Northern Power Corporation is completing a hydro-electric plant at "The Notch" on the Montreal River for the development of 13,000 hp., which has already been contracted for. In 1928 two new 18,500-kva. generating units were installed and placed in operation at the company's Quinze power station, but the needs of the territory have kept pace with the new power brought into use, and still more is required. During 1929 the company generated 347,797,617 kw.-hr. as compared with 342,887,750 kw.-hr. in 1928.

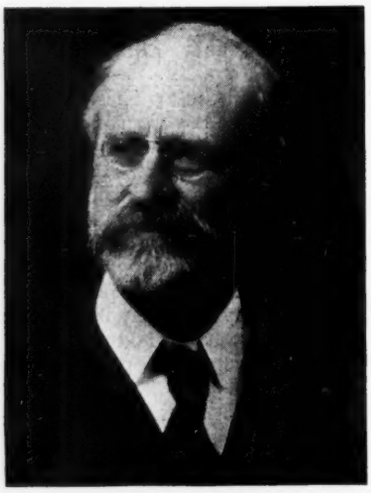
LITTLE PROGRESS has been made by the Power Corporation of Canada in its search for a water power capable of development to meet the needs of the Prince George district, according to C. F. K. Woodyatt, field engineer for the corporation. The Power Corporation had hoped to find a suitable water power quickly so that an offer could be made for the municipal power plant at Prince George, which is to be enlarged. This work was delayed awaiting a report from the Power Corporation, but on account of the trouble in getting a suitable flow of water to develop, corporation officials have admitted that the city would be wise to proceed with the enlarging of its municipal plant.

Satisfactory progress is reported by the Stuart Cameron Company of Vancouver, B. C., which is working on the $2,000,000 hydro-electric power and pulp plant for the Powell River Pulp & Paper Company at Stillwater. The contracting company expects the project to be completed by May, 1931.

Clemens Herschel, Hydraulic Engineer, Dies

Clemens Herschel, internationally known hydraulic engineer, inventor and past president of the American Society of Civil Engineers, died on March 1, at his home in Glen Ridge, N. J. Though in his 88th year, he went daily to his New York office until last fall, when his health failed.

Mr. Herschel was probably best known for his invention of the Venturi meter for the measurement of the flow



Clemens Herschel

of fluids in conduits, which is now in use throughout the world. For its invention he was awarded the Elliott Cresson gold medal by the Franklin Institute of Philadelphia.

Born in Boston, Mass., on March 23, 1842, Mr. Herschel graduated from Harvard University in 1860. From 1879 to 1889 he was connected with the Holyoke (Mass.) Water Power Company and was engineer and superintendent of the East Jersey Water Company from 1889 to 1900. During this time he engaged in engineering work for the Niagara Falls Power Company and helped organize the Cataract Construction Company, which erected the first power plant at Niagara Falls. Since then he had been doing consulting work.

A member of the Boston Society of Civil Engineers, the London Society of Civil Engineers and the Engineers' Club in New York City, Mr. Herschel was the author of several books on hydraulics, the most notable being "Frontinus and the Water Supply of Rome." This he wrote from notes and plans of Frontinus, which he found in an old monastery in Italy.

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GUY STERLING, who since 1900 had carried on a private practice in general engineering with headquarters in Salt Lake City, Utah, died in that city Feb. 23 of pneumonia at the age of 70. His practice included hydraulics, construction, power, mining, geology, litigation in mining and water rights.

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COMING CONVENTIONS

American Society of Mechanical Engineers. Fiftieth Anniversary Celebration at New York City, Hoboken, N. J., and Washington, D. C., April 5-9, 1930. Semi-Annual meeting at the Hotel Book-Cadillac, Detroit, Mich., June 9-12, 1930. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. District meeting at Springfield, Mass., May 7-10. Annual summer convention at Toronto, Canada, June 23-27. Secretary, F. L. Hutchinson, 33 West 39th St., New York City.

American Society of Heating & Ventilating Engineers. Annual summer meeting at the Curtis Hotel, Minneapolis, Minn., June 23-25. Secretary, A. V. Hutchinson, 33 West 39th St., New York City.

American Society of Refrigerating Engineers. Annual spring meeting at the Atlanta Biltmore Hotel, Atlanta, Ga., May 7-9. Secretary, David L. Fiske, 37 West 39th St., New York City.

American Society for Testing Materials. Annual meeting at Haddon Hall, Atlantic City, N. J., June 23-27. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

American Welding Society. Annual meeting at society headquarters in New York City, April 22-25. Secretary, M. M. Kelly, 33 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers. Annual convention and iron and steel exposition at Broadway Auditorium, Buffalo, N. Y., June 16-20. Managing director, John F. Kelly, Empire Building, Pittsburgh, Pa.

Canadian Electrical Association. Annual Convention at the Manoir Richelieu via the S.S. "St. Lawrence," June 11-13, 1930. Secretary, H. M. Lyster, 405 Power Building, Montreal, Quebec.

International Congress for General Mechanics at Liege, Belgium, Aug. 31 to Sept. 7, 1930. For information address Alb. Schlag, 4 Place Saint-Lambert, Liege, Belgium.

International Railway Fuel Association. Annual meeting at the Hotel Sherman, Chicago, Ill., May 6-9. Secretary, C. T. Winkless, Room 700, LaSalle St., Station, Chicago, Ill.

National Electric Light Association. Annual convention at Municipal Auditorium, San Francisco, Calif., June 16-20, 1930. Secretary, A. J. Marshall, 420 Lexington Ave., New York City.

National Oil and Gas Power Meeting, under auspices of A.S.M.E. Oil and Gas Power Division and Pennsylvania State College, will be held at State College, Pa., June 12-14. Chairman, L. H. Morrison, c/o *Power*, 10th Ave. and 36th St., New York City.

National Power Show. Held in connection with the International Textile Exposition at Mechanics Building, Boston, Mass., April 28 to May 3. For information, write to the New England Association of Commercial Engineers, 53 Devonshire St., Boston, Mass.

Second Plenary World Power Conference. Convenes at Berlin, German, June 16-25. Chairman of the American Committee, O. C. Merrill, Edmunds Building, Washington, D. C.

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Personals

H. BOYD BRYDON, chief mechanical engineer for the Byllesby Engineering & Management Corporation and for 21 years a member of the Byllesby organization, has resigned, effective March 17. Mr. Brydon was born in London, England, and educated at Finsbury Technical School. In 1900 he removed to Chicago, joining the firm of Sargent & Lundy as assistant engineer. In 1909 he joined the engineering department of H. M. Byllesby & Company. During his affiliation with the Byllesby organization he has worked on the design of many power plants.

JOSEPH W. BARKER, head of the department of electrical engineering at Lehigh University, has been appointed dean of the Faculty of Engineering at Columbia University. Professor Barker succeeds Professor GEORGE B. PEGRAM, who is retiring after thirteen years of service to engage in research.

EUGENE A. YATES, vice-president and general manager of the Alabama Power Company, has been elected vice-president and director of the Commonwealth & Southern Corporation. Mr. Yates was formerly chief engineer of the Alabama company and specialized in hydro-electric developments.

F. E. HARRELL has been appointed engineer in charge of the drafting and experimental departments of the Reliance Electric & Engineering Company of Cleveland, Ohio.

RICHARD H. BURKHART, former business manager of *Refrigerating Engineering*, has left this position to become associated with the Flakice Corporation of Newark, N. J.

OTTO A. BANNER, formerly chief engineer of the Diesel division of the Falk Corporation, has been retained by Busch-Sulzer Brothers-Diesel Engine Company, of St. Louis, Mo., to act exclusively for them as consultant in matters relating to Diesel engines and Diesel gear drives.

COL. PAUL DOTY, a member of the council of the American Society of Mechanical Engineers, has been appointed by Governor Christianson of Minnesota to a four-year term on the State Board for Registration of Architects, Engineers and Land Surveyors.

B. B. HOOD, for several years past chief engineer of the American Chain Company, has joined the staff of Procter & Gamble Manufacturing Company as assistant to the general superintendent at Ivorydale, Ohio.

CHARLES R. HIGSON, superintendent of distribution for the Utah Power & Light Company, Salt Lake City, has been elected president of the Engineering Council of Utah, the parent organization of local chapters of various engineering societies in that state.

Business Notes

PENNSYLVANIA PUMP & COMPRESSOR COMPANY, Easton, Pa., calls attention to the fact that the Kring-Becker Engineering Company, Mercantile Library Building, Cincinnati, Ohio, is its representative in the Cincinnati and Louisville districts, not the St. Louis district as stated in this column on Feb. 25.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., has received the Harvard Award for the "general or institutional advertising campaign conspicuous for the excellence of its planning and execution." Established by the late Edward W. Bok, the award consists of a certificate and cash prize of $2,000.

HENRY ADAMS, INCORPORATED, Baltimore, Md., is the name under which the organization of the late Henry Adams, consulting mechanical engineer, will continue the practice of engineering. Edward L. Crosby has joined the staff, which was associated with Mr. Adams.

ELLIOTT COMPANY, Jeanette, Pa., announces the appointment of Joseph J. Mullan as its New York manager. Mr. Mullan has for several years been located at the New York office as a condenser specialist.

JOPLIN MACHINERY & ELECTRIC COMPANY, Joplin, Mo., is the new name of the Machinery & Supply Corporation. The organization and personnel are unchanged, and the company continues to represent the Westinghouse Electric & Manufacturing Company, Pomona Pump Company, Gardner-Denver Company, Deming Pump Company, American Blower Company, George D. Whitcomb Locomotive Company and Dings Magnetic Separator Company.

CHESAPEAKE CRANE CORPORATION, Baltimore, Md., has appointed H. H. Knowles, 625 Third St., San Francisco, Calif., as its representative in New Mexico, Colorado, Wyoming, Montana, Idaho, Utah, Arizona, Nevada, California, Oregon and Washington.

CUTLER-HAMMER, INC., Milwaukee, Wis., announces the following changes in its sales organization: the Detroit district office has moved to 2755 East Grand Blvd., Detroit, Mich.; Frank J. Burd, electrical engineer, has been appointed manager of the Philadelphia office to succeed T. E. Beddoe, resigned; and M. C. Steffen is now manager of the Cincinnati office, replacing R. I. Maujer, who has resigned.

THE PERMUTIT COMPANY, New York City, announces the appointment of M. F. Corin as general sales manager. For the past fourteen years Mr. Corin has been sales manager of the Philadelphia district.

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With the SOCIETY SECTIONS

A.S.M.E., Metropolitan Section. Power division meeting in Room 501, Engineering Societies Building, on March 25 at 8 p.m. Subject: "Progress in the Use of High-Pressure Steam," by J. B. Crane, high-pressure specialist of the Combustion Engineering Corporation, New York City.

A.S.M.E., New Haven Section. Meeting at the Mason Laboratory on March 18 at 8 p.m. Subject: "Industrial Power," by P. W. Swain, associate editor of *Power*.

A.I.E.E., Niagara Frontier Section. Meeting at Niagara Falls Power House No. 2 on April 18. Subject: "Use of Regulators in Industry," by J. H. Ashbaugh, regulator engineer of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Cleveland Engineering Society. Fiftieth anniversary celebration meeting at the Hotel Hollenden, Cleveland, Ohio, on March 14-15.

Midwest Bituminous Coal Conference. Held under the direction of the Engineering Schools of Purdue University, Coal Trade Association of Indiana and Illinois Coal Bureau, at Lafayette, Ind., April 9-11. Chairman, W. A. Knapp, Purdue University, Lafayette, Ind.

New England States Association of the National Association of Power Engineers. Annual convention and exhibition of power machinery at the State Armory, Salem, Mass., June 19-20, 1930. Secretary, E. S. Daniels, 113½ Bridge St., Salem, Mass.

Northwest Electric Light & Power Association. Engineering section; seventh annual meeting at the Hotel Morck, Aberdeen, Wash., March 26-28. Secretary, B. H. Snow, 1206 Spalding Bldg., Portland, Ore.

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Trade Catalogs

MATERIAL HANDLING — An attractively illustrated 24-page booklet, GEA-1232, of the General Electric Company, Schenectady, N. Y., presents a detailed description of electric equipment for handling heavy material. Other recent bulletins of the company include: GEA-904C, on single-stage centrifugal air compressors for cupola blowing; GEA-1231, on quiet-operating induction motors; GEA-744A, on automatic network protectors for alternating current systems; GEA-474A, on truck-type switching equipment; GEA-945A and GEA-1196, on air circuit breakers; and GEA-1045A and GEA-19F, on switches.

HEATING — The Ric-Wil Company, Union Trust Bldg., Cleveland, Ohio, has just issued its annual edition of "Condensed and Tabulated Heating Rates," which covers heating system rates of 1929-30. Bulletin D, another new publication of the company, describes and illustrates sewer and drain products.

TURBINES—Small water turbines of the reaction, inward-flow or vortex type are described in a recent publication of the De Laval Steam Turbine Company, Trenton, N. J. Profusely illustrated, the bulletin contains engineering data, tables of constants and a chart for determining the resistance of pipes to the flow of water.

WELDING—A recent publication of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., points out some of the properties of cast iron and presents a recommended procedure to be followed in arc welding. Other new bulletins of the company include Leaflet 20400 on the application, operation and construction of motor-starting ammeters, and Leaflet A-07005 on polarity-insuring equipment for synchronous converters.

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Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard...	New York.....	$2.20 @$2.30
Kanawha.....	Columbus.....	1.40 @ 1.60
Smokeless.....	Cincinnati.....	2.00 @ 2.25
Smokeless.....	Chicago.....	2.25
S. E. Kentucky...	Chicago.....	1.35 @ 1.60
Steam.....	Pittsburgh.....	1.25 @ 1.60
Gas Slack.....	Pittsburgh.....	1.00 @ 1.15
Big Seam.....	Birmingham....	1.35 @ 1.50
Anthracite		
(Gross Tons)		
Buckwheat.....	New York.....	$2.50
Barley.....	New York.....	1.40@ 1.50

FUEL OIL

New York—Mar. 6, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75@5.5c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c. per gal.

St. Louis—Feb. 26, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.645 per bbl., or 42 gal.; 26@28 deg., $1.695 per bbl.; 28@30 deg., $1.745 per bbl.; 30@32 deg., $1.795 per bbl.; 32@36 deg., gas oil, 4.276c. per gal.; 37@40 deg., distillate, 4.98c. per gal.

Pittsburgh—Mar. 5, f.o.b. local refinery, 30@34 deg., fuel oil, 4.5@4.75c. per gal.; 36@40 deg., 4.75c.

Philadelphia—Feb. 18, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 22 deg. plus, $1.575@$1.625 per bbl.; 23@27 deg., $2.10@$2.15 per bbl.

Cincinnati—Feb. 25, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5.25c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.75c. per gal.

Chicago—Feb. 18, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 85@90c. per bbl.; 26@30 deg., $1.05@$1.10 per bbl.; 30@32 deg., $1.30@$1.35 per bbl.

Boston—Mar. 3, tank-car lots, f.o.b., 12@14 deg., Baumé, 3c. per gal.; 28@32 deg., 5c. per gal.

Dallas—Feb. 22, f.o.b. local refinery 26@30 deg., $1.35 per bbl. or 42 gallons.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ark., Mena—City plans an election Mar. 12 to vote $40,000 bonds for waterworks improvements including pumping equipment, mains, etc. Estimated cost $40,000.

Calif., Vallejo—City is having surveys made for the construction of a sewage pumping plant, pipe lines, etc. Estimated cost to exceed $25,000. T. D. Kilkenny, is city engineer.

Conn., Middletown—Wesleyan University, M. Davis, plans the construction of a boiler house. Estimated cost $40,000. McKim, Meade & White, 101 Park Ave., New York, N. Y., are engineers.

Conn., Watertown—Taft School, H. D. Taft, Pres., Bd. of Trustees, awarded contract for the construction of a boiler house to T. J. Pardy Construction Co., 1481 Seaview Ave., Bridgeport. Estimated cost $40,000.

D. C., Bennings—Potomac Electric Power Co., 231 14th St. N.W., Washington, awarded contract for the design and construction of addition to Benning station and installation of a 30,000-kw. generator here to Stone & Webster Engineering Corp., 49 Federal St., Boston, Mass. Estimated cost $3,000,000. Contractor will receive bids in April for materials, equipment, etc.

Mass., Lynn—City plans the construction of a police station, garage and boiler house. Estimated cost $200,000. Architect not selected.

Miss., Pascagoula—Pascagoule Cold Storage & Ice Co., Inc., W. Lindinger, is having plans prepared for the construction of an ice plant. Estimated cost $45,000. E. K. Strahan, Pere Marquette Bldg., New Orleans, is consulting engineer. Owner taking separate bids on equipment.

N. J., East Orange—Oraton Realty Co., J. Kriger, St. Francis Hotel, 24 East Park St., Newark, will receive bids about Apr. 1 for the construction of a 6 story hotel including steam heating system, boilers, elevators, etc., at Lincoln and Winchester Sts. Estimated cost $500,000. Warren & Warren, 31 Clinton St., Newark, are architects.

N. J., Jersey City—Harris & Sohn, 58 Park Pl., Newark, Archts., will receive bids about Mar. 15 for the construction of a medical office building including steam heating and ventilation systems, boilers, elevators, etc., at Tonnelle and Sip Aves. here for Journal Sq. Medical Building, Inc., W. J. Quinn, Pres., c/o Dept. of Revenue & Finance, City Hall. Estimated cost $1,000,000.

N. J., Trenton—State Bd. of Education, State House, will receive bids until Mar. 19 for the construction of a power house at Trenton Normal School at Pennington Rd. Estimated cost $40,000. Guilbert & Betelle, 20 Branford Pl., Newark, are architects.

N. Y., New York—Rubel Coal & Ice Co., 937 Fulton St., Brooklyn, plans the construction of a 1 story manufacturing and ice storage building at Eagle Ave. and 158th St. here. Estimated cost $100,000. H. J. Nurick, 44 Court St., Brooklyn, is architect and engineer.

N. Y., Pleasantville—Westchester Light Co., 9 South First Ave., Mount Vernon, will receive bids about Apr. 1 for the construction of a substation, service building, etc. here. Estimated cost $150,000. Private plans.

N. Y., Willard — Dept. of Mental Hygiene, Albany, awarded contract for addition to power plant at Willard State Hospital here, to Havens Construction Co., 115 West State St., Olean. Estimated cost $27,930.

N. D., Fargo—Union Storage & Transfer Co., awarded contract for the construction of a 100 x 115 ft. cold storage warehouse, 76 x 132 ft. creamery, etc., to Meinecke & Johnson Co. Estimated cost $250,000.

O., Apple Creek—Dept. of Welfare, A. T. Connar, Ninth and Oak Sts., will receive bids until Mar. 25 for the construction of a 60 x 72 ft. power house at Institution for Feeble Minded here. Estimated cost $75,000. T. R. Ridley and G. W. Drach, Ohio-Hartman Bldg., Concinnati, are engineers.

Okla., Tecumseh—City awarded contract for the construction of a 500 hp. Diesel engine electric light plant, to J. F. Pritchard & Co., 528 Dwight Bldg., Kansas City, Mo. Estimated cost $25,000.

Pa., Morrisville — Philadelphia Electric Co., 10th and Chestnut Sts., plans the construction of a booster station at South Pennsylvania Ave. and Green St. Estimated cost $200,000.

Pa., New Castle—Stevens & Wood, 60 John St., New York, N. Y., Engrs. and Contrs., are receiving bids on construction and equipment for power sub-station and service building here for Pennsylvania Power Co., Sharon. Estimated total cost $250,000. Work will be done by separate contracts.

Pa., Pittsburgh—City Ice & Fuel Co., H. D. Norville, Pres., 6611 Euclid Ave., Cleveland, O., is having plans prepared for the construction of and equipment for a cold storage and ice manufacturing plant, 300 ton daily capacity at 15th, Pike and Penn Sts. Estimated cost $2,500,000. Ball Ice Machine Co., 126 Chouto St., St. Louis, Mo., is engineer. W. Schmidt, c/o owner is company engineer.

Pa., Pittsburgh—Consolidated Ice Co., 13th and Pike Sts., plans the construction of a 7 story, 100 x 350 ft. ice and storage plant. R. Lochmiller, 13th and Pike Sts., is company engineer.

Pa., Reed—Standard Oil Co. of Pennsylvania, Peoples Gas Bldg., Pittsburgh, awarded contract for the construction of a relay terminal including 28 x 45 ft. boiler house, 45 x 65 ft. pump house, 55 x 65 ft. coal house, etc. here, to H. Busse Co., 112 Wabash Ave., Pittsburgh.

Wis., Milwaukee—Holabird & Root, 333 North Michigan Ave., Chicago, Ill., will receive bids until Mar. 17 for the construction of an 8 story office building including steam heating system, elevators, etc. on Mason St., for Northwestern Mutual Life Insurance Co., 210 East Wisconsin Ave. Estimated cost $2,800,000.

Ont., London—Hotel London, R. Lussier, will receive bids until Apr. 1 for the construction of an 8 story hotel including steam heating system, etc. on Dundas St. Estimated cost $500,000. J. M. Moore, 489 Richmond St., is architect.

Ont., London—Huron & Erie Mortgage Corp., M. Aylesworth, Gen. Mgr., will receive bids until Apr. 1 for the construction of a 10 story office building including steam heating system, etc. on Dundas St. Estimated cost $1,000,000. Watt & Blackwell, Bank of Toronto, are architects. Goggin & Ripley, 28 Pine St., New York, N. Y., are associate architects.

Ont., Simcoe—Norfolk Fruit Growers' Association, is having plans prepared for the construction of a 4 story, 80 x 80 ft. cold storage and pre-cooling plant. Estimated cost $100,000. E. H. Darling, 36 James St., Hamilton, is engineer.

Equipment Wanted

Boiler and Stoker—Somerset Hills, N. J.—U. S. Veterans' Bureau, Arlington Bldg., Washington, D. C., will receive bids until Mar. 25 for furnishing and installing boiler and stoker at U. S. Veterans' Hospital here.

Condensers—Brooklyn, N. Y.—Signal Supply Officer, New York General Depot, 58th St. and First Ave., will receive bids until Mar. 18 for condensers, fixed, mica, 1 mfd., plus or minus 10%, working voltage 1750 v., Dubilier type 653, or Faradon type UC-2209-E, with No. 56 case.

Fans, Air Compressors—Gallitzin, Pa.—Pennsylvania R.R., T. J. Skillman, Ch. Engr. Broad St. Station, Philadelphia, is receiving bids for eight large motor driven fans, in west bound track tunnels Nos. 3 and 4 here at Crest Allegheny Mountains, installing unit air compressors at four towers to pull smoke from tunnels at speed in excess of that of trains passing through to keep air clear.

Engine—Malden, Mass.—M. C. Meyers, 20 Wadsworth St., is in the market for a 40 to 70 hp. belt driven steam engine figured at 40 lbs. M.E.P.

Generator—Boston, Mass.—Auto Sickle Co., 53 State St., is in the market for a 15 kw. single ph. a.c. generator, 220 v. platform truck to take platforms 24 x 30 x 8 in.

Pumping Equipment—Green Isle, Minn.—City, F. P. Michaletz, Recorder, plans to purchase pumping equipment, etc. for proposed waterworks improvements. Estimated cost $20,000.

Pumping Equipment — Toronto, Ont. — City plans to purchase electrically driven centriifugal pumping equipment for proposed extension to Riverdale pumping station. Estimated cost $65,000.

Pumps—Coral Gables, Fla.—City will receive bids until Mar. 17 for the installation of Worthington pumps in proposed waterworks pumping station.

Pumps—Dickinson, N. D.—City plans to purchase two turbine pumps and one 1,500 g.p.m. pump for proposed waterworks system.

Pumps, etc.—Delta, O.—Bd. of Public Works, will receive bids until Apr. 1 for two 700, one 250 and two 2,800 g.p.m. pumps for proposed waterworks system. Estimated cost $100,000.

Pumps, etc.—Ont., Colborne.—Town plans to purchase electric pumps, etc. for proposed extension to waterworks. Estimated cost $60,000.

Refrigerating Machines — Warrendale, Pa.—Thorn Hill School, F. H. Briggs, Supt., is receiving bids for two 6 ton refrigeration machines, electrically driven with ammonia condensers, brine pumps, etc.

Sub-Station Equipment—Altoona, Pa.—Pennsylvania Central Light & Power Co., additional equipment to increase capacity of existing substation from 1,500 to 6,000 kva. Estimated cost $160,000.

Industrial Projects

Calif., Omona—Pomona Pump C[illegible] having plans prepared for the construction [illegible] group of factory buildings. Private pla[illegible]

Conn., East Hampton—N. N. Hill Brass C[illegible] 25 Skinner St., Hampton, awarded contract f[illegible] a 2 story, 40 x 100 ft. factory to N. P. Cl[illegible] 350 Ridge Rd., Wethersfield. Estimated [illegible] $40,000.

Mass., Cambridge (Boston P. O.) — Gen[illegible] Radio Co., M. Eastham, 30 State St., is having plans prepared for the construction of a 4 story factory on State St. Estimated cost $80,000. Lockwood Greene Engrs., Inc., 24 Federal St., Boston, are engineers.

Mass., Everett (br. Boston)—C. L. Betton, 31 Exchange St., Lynn, Archt., will receive bids until Mar. 15 for addition and alterations to factory, 40 x 175, 40 x 115 and 40 x 85 ft. for Boston Varnish Co., Boston and Second Sts. Estimated cost $140,000 to $160,000.

Mass., Springfield—Granville Bros. Aircraft Corp., Z. H. Granville, Pres., 1211 Liberty St., plans the construction of a factory at Fisk Airport. Estimated cost to exceed $40,000. Architect not selected.

N. J., Newark—General Alloy Co., 188 New Jersey Railroad Ave., is having plans prepared for the construction of a 2 story factory at Maple Pl. Estimated cost $40,000. P. B. West, 24 Commerce St., is architect.

N. J., Keasby—General Ceramics Co., will soon award contract for a 1 story, 80 x 130 ft. addition to factory including kiln furnaces, dryer, etc. Estimated cost $50,000. D. Wortmann, 116 Livingston Ave., New York, is architect.

N. J., Newark—Newark Special Tool & Machine Co., 51 Lawrence St., is having preliminary plans prepared for the construction of a 1 story, 90 x 110 ft. factory at 87-95 St. Francis St. Estimated cost $40,000. M. B. Silberstein, 964 Broad St., is architect.

N. J., Trenton—Trenton Potteries Co., North Clinton and Ott Sts., awarded contract for addition to factory No. 6, 5 story, 65 x 168 ft. on Dewey St. to Karno Smith Co., Broad St., Bank Bldg. Estimated cost $150,000.

O., Kenmore—Palmer Match Co., plans the construction of a 1 story, 60 x 150 ft. factory on Corey Ave. Estimated cost $50,000. Private plans.

O., Willoughby—Weller Pottery Co., Zanesville, awarded contract for a 40 x 100 ft. factory at Mentor Ave. on Route 40, to C. O. Vinsel & Son, Zanesville. Estimated cost $40,000.

Okla., Oklahoma City—Cromwell Franklin Oil Co., Franklin Bldg., is having preliminary plans prepared for the construction of an oil refinery for greases and oils. Estimated cost $1,000,000. Private plans.

Pa., East Freedom—Standard Oil Co. of Pennsylvania, W. E. Black, in charge, will receive bids until Mar. 12 for the construction of a distribution plant including power house, 15 tanks, etc. Private plans.

Pa., Lewistown—Viscose Co., Marcus Hook, awarded contract for the construction of a 1 story, 225 x 330 ft. factory here, to Wark Co., 1608 Walnut St., Philadelphia.

Pa., New Britain—Victor Silk Hosiery Co., Willow Grove, awarded contract for the construction of a 1 story 105 x 115 ft. hosiery mill, 40 x 50 ft. dye plant and 40 x 40 ft. power plant here, to T. Gagliardi, 8249 Frankford Ave., Philadelphia.

Tex., El Paso—Houston Cooperage & Tub Co., 3100 Canal St., Houston, is receiving bids for the construction of a 1 and 2 story factory including equipment here. Estimated cost $80,000. Private plans.

Tex., Sweetwater — International Harvester Co., c/o N. Roberts, Br. Mgr., received lowest bids for the construction of a 1 and 2 story, 100 x 300 and 100 x 183 ft. factory from Kucharo Construction Co., 1342 South Flores St., San Antonio. Estimated cost $175,000.

W. Va., Welrton—Weirton Steel Co., awarded contract for the construction of a rail and structural mill, to United Engineering & Foundry Co., Farmers Bldg., Pittsburgh. Estimated cost $3,500,000.

Wis., Milwaukee—E. Weiner Co., 297 7th St., awarded contract for a 2 story, 50 x 150 ft. furniture factory, to Selzer-Ornst, 44 East State St., Wauwatosa. Estimated cost $40,000.

Ont., Fort William—Canadian Terminal System, 34 King St. E., Toronto, plans the construction of a gas and coking plant here. Estimated cost $1,000,000. Private plans. Equipment will be required.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

HIGHER prices become effective this month on black and galvanized conduit at New York warehouses. Cold-drawn steel dropped 10c. per 100 lb., to $3.40 for round or hexagon and $3.90 for flat or square, compared with February levels. Genuine, highest grade babbitt is down 1c. per lb., to 57c., delivered in case lots.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 60c. per ft.
Common, 2½-in., cotton, rubber-lined, 80c. per ft., list, less		50%

Air—Best grade

¾-in., per ft.	3-ply....$0.30	4 ply....$0.36

Steam—Discounts from List

First grade....40%	Second grade.....45%	Third grade....50-10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade.....50%	Second grade.....60%

LEATHER BELTING—List price, 24c. per lin.ft., per inch of width, for single ply, at New York warehouses:

Grade	Discount from list
Medium	30-10%
Heavy	30%

RAWHIDE LACING—For cut, best grade, 30-5%; 2nd grade, 45-5%. For laces in sides, best, 57c. per sq.ft.; 2nd, 52c., net. Semi-tanned, cut, 30-5%.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.75
Duck and rubber for piston packing	.90
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.85
Wire insertion asbestos sheet	1.20
Rubber sheet	.45
Rubber sheet, wire insertion	.75
Rubber sheet, duck insertion	.55
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts from list at New York warehouses are as follows:

85% magnesia, high pressure		40 %
Asbestos, air cell, for low-pressure heating and return lines	4-ply	65 %
	3-ply	67½%
	2-ply	70 %

PORTLAND CEMENT—New York, $2.30 per bbl., without bags, delivered by truck to site of job. Bag charge, 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, beams and channels, 3 to 15-in.; angles, 3 to 6-in., ¼-in. thick; tees, 3-in. and larger; and plates, ¼-in. thick and heavier; all $3.30 per 100 lb. in lots up to 3,999 lb.

COTTON WASTE—The following prices are in cents per lb., at warehouse:

	New York	Cleveland	Chicago
White	13.00	16.00	15.00
Colored	9.50	12.00	12.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed white wipers, as follows:

Chicago (100 lb. bales)	$0.16
New York (100 lb. bales)	.12½
Cleveland (per thousand)	38.00

LINSEED OIL—These prices are for raw oil in barrels, f.o.b., in 1 to 4 bbl. lots:

	New York	Cleveland	Chicago
Per pound	$0.148	$0.164	$0.154

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b., New York:

	Dry	In Oil
Red	$13.75	$15.25
White	13.75	14.25

RIVETS—The following quotations apply on fair-sized orders from warehouse:

Tank rivets, ½-in. diameter and smaller, list (Apr. 1, 1927) less 60% in full packages, for immediate delivery from warehouse stocks in New York and vicinity.

Structural rivets, ½-in., round head, per 100 lb.:

New York	$4.50*
Chicago	4.00
Pittsburgh mill	3.10

*This price is for full kegs; broken kegs are $6.00 per 100 lb.

REFRACTORIES—Prices in car-loads, f.o.b. plant:

Chrome brick, eastern shipping points	per net ton	$45.00
Chrome ore, ground, 40@50%, Cr_2O_3, in bulk	per net ton	22@25
Chrome ore, ground, 40@50%, Cr_2O_3, in sacks	per net ton	26@29
Chrome ore, crude, 40@50%, Cr_2O_3	per net ton	18.00@22.50
Magnesite brick, 9-in. straights	per net ton	65.00
Magnesite brick, 9-in. arches, wedges and keys	per net ton	71.50
Magnesite brick, soaps and splits	per net ton	91.00
Silica brick, Mt. Union, Pa	per M	43.00
Clay brick, 1st quality, 9-in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38

BABBITT METAL—Delivered in case lots from New York warehouse, on orders of 100 lb. or over, cents per pound:

Genuine, highest grade	57.00
Commercial genuine, intermediate grade	42.00
Anti-friction metal, general service	31.00
No. 4 babbitt, f. o. b.	11.50

COLD DRAWN STEEL—Shafting and screw stock, warehouse prices per 100 lb., base, are as follows:

	New York	Cleveland	Chicago
Round or hexagon	$3.40	$3.65	$3.60
Flat or square	3.90	4.15	4.10

BOILER FITTINGS—F.o.b. warehouse, Jersey City, N. J., discounts from list:

Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	20%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following basing discounts from list are for large mill lots at Pittsburgh mill:

BUTT WELD

Steel Inches	Black	Galv.	Iron Inches	Black	Galv.
1 to 3	62%	50½%	1 and 1¼	31%	15%

LAP WELD

2	55%	43½%	2	23%	9%
2½ to 6	59%	47½%	2½ to 3½	28%	13%
7 and 8	56%	43½%	4 to 6	30%	17%
9 and 10	54%	41½%	7 and 8	29%	16%
11 and 12	53%	40½%	9 to 12	26%	11%

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60%	49½%	1 to 2	34%	18%
2 to 3	61%	50½%			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53%	42½%	2	29%	13%
2½ to 4	57%	46½%	2½ to 4	34%	20%
4½ to 6	56%	45½%	4½ to 6	33%	19%
7 and 8	52%	39½%	7 and 8	31%	17%
9 and 10	45%	32½%	9 to 12	21%	8%
11 and 12	44%	31½%			

BOILER TUBES—Standard gage, manufactured in accordance with the specifications and requirements of the American Society of Mechanical Engineers and in compliance with the rules and regulations of the U. S. Steamboat Inspection Service, from New York warehouse stock, per 100 ft.:

Size, Inches*	B.W.G.	Toncan Seamless Iron	Knobbled Charcoal Iron	Seamless Steel	Lapwelded Steel
1	13	$34.00	.....	$18.00	.....
1¼	13	37.75	.....	20.25	.....
1½	13	38.00	$38.00	19.25	.....
1¾	13	30.00	30.00	22.00	.....
2	13	26.25	26.25	20.25	$19.00
2¼	13	34.50	34.50	23.00	25.00
2½	12	34.00	34.00	26.00	24.25
2¾	12	40.50	40.50	28.50	27.50
3	12	42.50	42.50	27.00	25.50
3¼	11	50.25	50.25	30.75	28.75
3½	11	54.50	54.50	33.25	31.50
4	10	67.00	67.00	40.00	38.00

These prices are based on stock lengths. If cut to special lengths billing will be based on the entire stock lengths. In addition to the foregoing, standard cutting charges are as follows:

2-in. and smaller..	$0.05 per cut	3-in.....	$0.09 per cut
2¼ and 2½ in.....	.06 per cut	3¼ to 4 in..	.10 per cut

*External diameter.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft., New-Style, A.B.C., with fibre bushing:

B. & S. Size	BX Two Cond. M. Ft.	BX Three Cond. M. Ft.	Lead Two Cond. M. Ft.	Lead Three Cond. M. Ft.
No. 14 solid....	$33.85 (net)	$48.00 (net)	$180.00	$220.00
No. 12 solid....	136.00	180.00	225.00	275.00
No. 10 solid....	185.00	235.00	275.00	325.00
No. 8 stranded..	305.00	375.00	420.00	500.00
No. 6 stranded..	440.00	530.00	615.00	.....

From the above lists discounts are:	BX	Lead Covered
Less than coil lots	50%	30%
Coils to 1,000 ft.	60%	34%
1,000 to 5,000 ft.	63%	36%
5,000 ft. and over	65%	48%

CONDUIT—Rigid iron, price per 1,000 ft.; **ELBOWS AND COUPLINGS,** per 100 pieces, extra. New York warehouse shipment. Discount of 5 per cent for payment in 10 days; 30 days net.

Size, Inches	GALVANIZED Conduit	GALVANIZED Elbows	GALVANIZED Couplings	BLACK Conduit	BLACK Elbows	BLACK Couplings
¼	59.96	8.33	4.79	54.95	6.56	4.14
⅜	76.50	10.97	6.84	69.81	8.64	5.91
1	109.90	16.24	8.90	99.79	12.79	7.69
1¼	148.69	21.97	12.48	135.03	17.78	10.89
1½	177.76	29.31	15.41	161.46	23.72	13.45
2	239.20	54.71	20.55	217.25	43.47	17.95
2½	378.19	87.91	29.36	343.51	71.15	25.63
3	494.56	234.10	44.04	449.22	193.36	38.45
3½	621.96	516.92	58.74	567.64	418.05	51.30
4	758.30	597.18	73.41	693.95	483.13	64.10
4½	884.36	904.12	110.00	809.43	731.42	96.13
5	1029.65	1255.26	121.13	942.33	1015.53	105.76
6	1335.66	1560.33	176.12	1222.39	1262.41	153.78

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less Than $10 List	$10 List to $100	$100 List and Over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices, each, in standard-package quantities:

CUT-OUTS, PLUG, SOLID, NEUTRAL OR 2-FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID, NEUTRAL OR 2-FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$21.50
No. 16 cotton reinforced heavy		25.00
No. 18 cotton reinforced light		15.50
No. 16 cotton reinforced light		22.00
No. 18 cotton Canvasite cord		17.00
No. 16 cotton Canvasite cord		27.00
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$70.80	*76.70
No. 14 super service cord or similar (2 wire) in 1,000 ft.	106.20	*115.05

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List Each
3-amp. to 30-amp.,	100	$0.15	3-amp. to 30-amp.,	100	$0.30
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
61-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
101-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
201-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
401-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less than one-fifth standard package, 60%; one-fifth to standard package, 65%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.....	$0.50	$1.10	100	10
35 to 60-amp.....	1.00	1.25	100	10
65 to 100-amp.....	2.00	3.00	50	5
110 to 200-amp.....	4.00	5.00	25	5
225 to 400-amp.....	7.50	11.00	25	1
450 to 600-amp.....	11.00	16.00	10	1

REFILLS—

1 to 30-amp.....	$0.03 ea.	$0.05	100	100
35 to 60-amp.....	.05 ea.	.06	100	100
65 to 100-amp.....	.10 ea.	.10	50	50
110 to 200-amp.....	.15 ea.	.15	25	50
225 to 400-amp.....	.30 ea.	.30	25	25
450 to 600-amp.....	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken cartons	Net list
Unbroken cartons	17%
Ten unbroken cartons	34%
Discount Without Contract—Renewals:	
Broken cartons	Net list
Unbroken cartons	17%
Ten unbroken cartons	34%
Discount With Contract—Fuses:	
Broken cartons	5%
Unbroken cartons	20%
Ten unbroken cartons	36%
Discount With Contract—Renewals:	
Broken cartons	Net list
Ten unbroken cartons	36%

Carton quantities may be combined to obtain maximum discounts.

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500), per 100	$2.80
0–30 ampere, less than standard package, per 100	3.10

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard, A type bulbs:

100—130 Volt Watts	General Type	Price Each	200—260 Volt Watts	Special Type	Price Each
15	A 17	$0.20	25	A 19	$0.25
25	A 19	.20	50	A 21	.25
40	A 21	.20	100	A 23	.45
50	A 21	.20	...	.....	.....
60	A 21	.20	...	.....	.....
100	A 23	.35	...	.....	.....

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net, allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain, separable, attachment plug	$0.18
Composition, 2-piece, attachment plug	.27
Swivel attachment plug	.12
Small size, 2-piece plug, composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f.o.b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$6.50	$8.90	$11.20	$19.00
12	9.90	11.40	14.00	25.00
10	13.50	15.40	18.50	33.50
8	19.90	22.50	25.00	47.50
6	.....	.....	36.00	.....
4	.....	.....	52.00	.....
2	.....	.....	72.00	.....
1	.....	.....	97.00	.....
0	.....	.....	119.00	.....
00	.....	.....	143.00	.....
000	.....	.....	176.00	.....
0000	.....	.....	215.00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Key	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.12	$0.10	$0.16	$0.16½	$0.14	$0.20
Unbroken carton	.14	.12	.18	.18	.16	.21
Broken carton	.16	.14	.20	.20	.18	.24

WIRING SUPPLIES—

Friction tape, ¾ in., in less than 100 lb., 31c. per lb.; in 100 lb. lots, 29c. per lb
Rubber tape, ¾ in., in less than 100 lb., 33c. per lb.; in 100 lb. lots, 31c. per lb
Wire solder, in less than 100 lb., 33c. per lb.; in 100 lb. lots, 31c. per lb.
Soldering paste, 2 oz. cans ..... $1.10 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$3.50	$5.70	$9.00
60	9.00	11.00	14.00
100	14.00	17.00	29.00
200	22.00	29.00	48.00

Discounts:	
Standard package	40%
Less than standard package	35%